JUNE, 1956

PIPE LINE INDUSTRY

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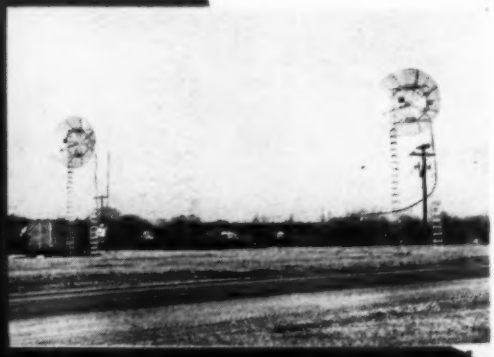
New herbicides cutting weed and brush control costs up to 80 percent

Page 46

5 PAPERS FROM THE API PIPE LINE CONFERENCE

Page 26



New UHF Transhorizon systems . . . . . How can pipe lines use them?

Page 54

n the page for additional contents and Quick Review of this issue

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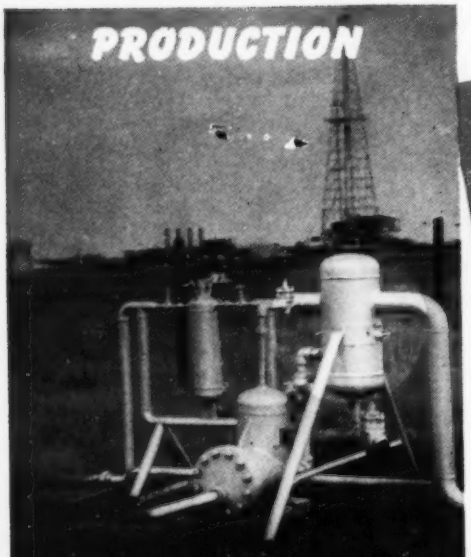
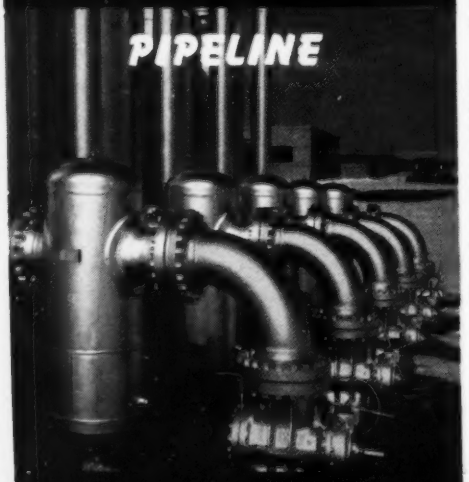


Pictured above is a Peerless Line Separator removing moisture from fuel to drilling rig.

REFINING

These two Peerless Line Separators are doing an efficient job of mist extraction in the Petrochemical plant in Kentucky.

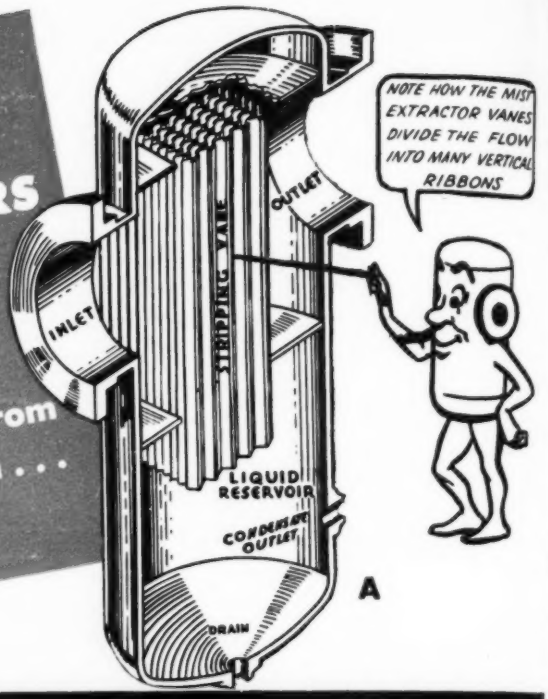
PIPELINE

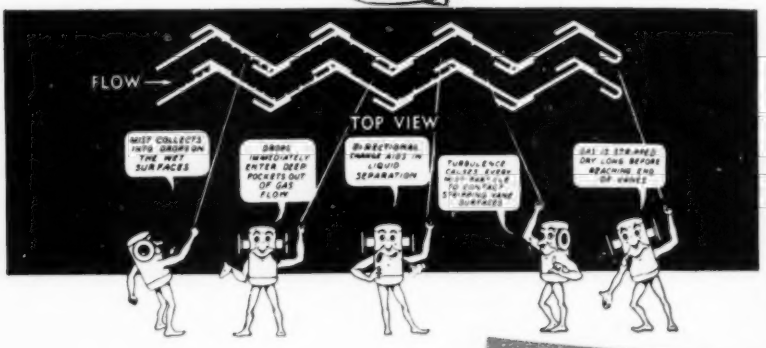


FIVE Peerless Line Separators are shown above as they handle carry over from large scrubbers.

PEERLESS LINE SEPARATORS

Outstanding for the efficient extraction of liquid mist from gas or steam . . .




B
FLOW
TOP VIEW
MIST COLLECTS INTO DROPS ON THE WET SURFACES
DROPS IMMEDIATELY ENTER DEEP POCKETS OUT OF GAS FLOW
BI-DIRECTIONAL CHANGE AIDS IN LIQUID SEPARATION
TURBULENCE CAUSES EVERY MIST PARTICLE TO IMPINGE ON THE STRIPPING VANE SURFACES
GAS IS STRIPPED DRY LONG BEFORE REACHING END OF VANES

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PIPE LINE INDUSTRY

CONTENTS and Quick Review

June, 1956 Vol. 4, No. 6

To help you put first things first, scan these time-saving digests, checking ☑ those you want to read first.

Fluid Temperature Rise Equals Pump Efficiency

☐ This simple test tells the condition of engine-driven centrifugal pumps and their operating efficiency quickly and accurately. Phillips engineers have proved the method in extensive field tests. Temperature rise in the pump, gravity and pump differential pressures are the only measurements required.

G. P. Jennings and L. P. Meade.....Page 26

Automatic Measurement of Crude Oil

☐ Automatic measurement and control is the hottest topic among pipeliners at any meeting. Here are some of the views about what is ahead for the industry. Improved instruments and personnel training are the keys to successful acceptance in pipe line operations.

M. H. Atkinson and A. H. Newberg.....Page 30

Unique Problems on NATO Pipe Lines

☐ Problems of building pipe lines in the U. S. may seem tough—and they often are—but some of the problems faced by the builders of the NATO systems in Europe are amazing. Lack of equipment, labor problems and legal regulations created new difficulties for American pipeliners.

J. R. Shipley.....Page 33

Computers Speed Products Scheduling

☐ Better scheduling is on the way for complex products pipe line networks. Great Lakes Pipe Line Company has worked out basic solutions to problems with an electronic computer research team. Plans call for a larger machine for full-scale planning.

D. L. Fayman.....Page 35

Dampening High-Speed Pump Pulsations

☐ This new design uses the slight compressibility of pumped liquid in a chamber connected to the pipe line by a reduced-diameter choke tube. It is of particular economic interest for high-speed pumps. Here is a mathematical analysis of pulsation effects with a description of the means to control them.

Milton Ludwig.....Page 38

API Starts Pipe Line School

☐ Course is planned primarily for supervisors and prospective leaders. All major phases of pipe line transportation will be treated with emphasis on economic factors and costs. First six-week session starts this fall at Lee College, Baytown, Texas.....Page 45

Chemicals Speed Brush Control on Right-of-Way

☐ New type herbicides are cutting weed and brush control costs up to 80 percent in maintaining right-of-way for operations and future construction. Proper chemicals and techniques are essential to get best results from these herbicides.

J. F. Allen.....Page 46

7-Mile Colombian Pipe Line Stretch One of the Toughest

☐ One seven-mile section of the 64-mile, $5.2 million Buenaventura-Cali pipe line built for Empresa del Oleoducto Buenaventura-Cali, Ltda., has been described as one of the roughest and most difficult pipe lines of its size ever built. For details on this section—and the entire project—don't miss this story.....Page 50

What About UHF Scatter Systems for Pipe Lines?

☐ These systems offer interesting possibilities for pipe line communications where long circuit hops are common. The big question—How much spectrum will be used? Results of field studies indicate the "scatter" systems have promise.

R. M. Ringoen.....Page 54

25 Tips From Top Supervisors

☐ Even with the increasing use of automatic controls, the effective leader is still the most valuable pipeliner. Here are 25 tips from successful supervisors that will help you do your job better.....Page 60

Who Read Your Last Report?

☐ Chances are that it went unread if it was poorly written. Here are some down-to-earth pointers that will whet your interest in writing better reports.

W. B. Etheridge.....Page 62

REGULAR MONTHLY DEPARTMENTS

Editorial Page 4
Rules of Thumb 59
Construction News 66
Pipe Line Hints 82
Personals 95
Who's Meeting Where 102
Suppliers' Notes 104
What's New in Equipment 118
New Equipment Catalogs and Literature 125
ADVERTISERS' INDEX 126

PIPE LINE INDUSTRY published every month. Entered as second class mail matter July 9, 1954, at the post office at Houston, Texas, under the act of March 3, 1879.

Government Regulation Is Always Bad

Presidential veto of the natural gas bill has brought another U. S. industry under government control. The producers of natural gas are to be controlled as well as the gas transmission companies.

Therefore, it is fitting at this time to look into the question of how other businesses have fared when placed under government regulation. Railroads make an ideal subject. Since much of the nation's freight moves by railroad, they have a significant bearing on the prices people pay for most commodities.

•

Until the 1920's railroads had a monopoly on all long distance land traffic. Horses were their only competitor. As a monopoly they had been placed under government control. This monopoly ceased to exist long ago, but railroads continue to be run by the government.

Today, there are over 61 million automobiles, trucks and buses in the U. S. There are over 65,000 private and commercial airplanes, 175,000 miles of crude oil and petroleum product pipe lines, and approximately 15,000 inland waterway vessels. Each of these units, either occasionally or frequently, is a direct competitor of the railroads today.

Consequently, railroads now handle only 49 percent of all intercity freight. Trucks, pipe lines and inland water carriers handle the balance. Today 87 percent of all intercity travel is by private automobile, 5 percent by bus, and 3 percent by air, while only 5 percent is by rail.

•

The federal government continues to apply just as firm and resolute rules and regulations as it did 30 years ago although railroads ceased to be a monopoly long ago.

Railroads are not free to offer the public the lowest possible rates. They often are required to maintain rates higher than they desire. Lower rates might attract business from a competitor, and federal regulatory authorities are charged with the responsibility of dividing the nation's traffic among various types of carriers.

No form of transportation has a monopoly today. Consequently, the historic concept of U. S. free enterprise and equal opportunity should be applied to the transportation field. Each type possesses certain advantages in handling different kinds of shipments and traffic. Each type of carrier should be given the opportunity to do the best job. Otherwise, the public is being robbed.

•

American people travel over half a trillion miles annually. Their freight shipments amount to more than one trillion ton-miles of intercity traffic. The bill for this volume of travel and freight shipments is estimated at $50 billion yearly.

Such a huge expenditure obviously taps the pocketbook of every citizen. It is to the interest of the public that competition be permitted and even encouraged, so as to provide the best and cheapest means.

How can it be unfair to let all forms of transportation compete under open competition with one another, so long as a monopoly does not exist. Only the public and the railroads lose by unfair regulation of one type of transportation.

•

So it will be with the natural gas producing industry. The producers of this commodity should not be regulated, nor should competing fuels. The benefits of free competition should be passed on to consumers.

Furthermore, government regulation imposes large and unnecessary costs. Government bureaus must hire personnel, rent offices, etc. These costs must be paid for by higher taxes. To regulate gas producers, the Federal Power Commission must greatly enlarge its personnel. This will cost money.

•

Government regulation of any business does not pay. Neither the business, the country, nor the public benefits. The only reason for government regulation is in the case of monopolies.

Americans must wake up to this fact. They must start to fight for freedom before it is too late. Freedom in business is just as important to the U. S. as freedom of religion, freedom of speech, or any other freedom.

Warren L. Baker

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An editorial . . .

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As the Associated Business Publications celebrates its Golden Anniversary, then, we take this opportunity and this space to re-pledge our support of the high publishing principles for which it stands and to re-assure each and every one of our readers that we will ever *"consider, first, the interests of the subscriber."*

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WORLD OIL and **THE COMPOSITE CATALOG** for the drilling-producing-pipe line industry.

PETROLEUM REFINER and **THE REFINERY CATALOG** for the refining-natural gasoline-petrochemical industry.

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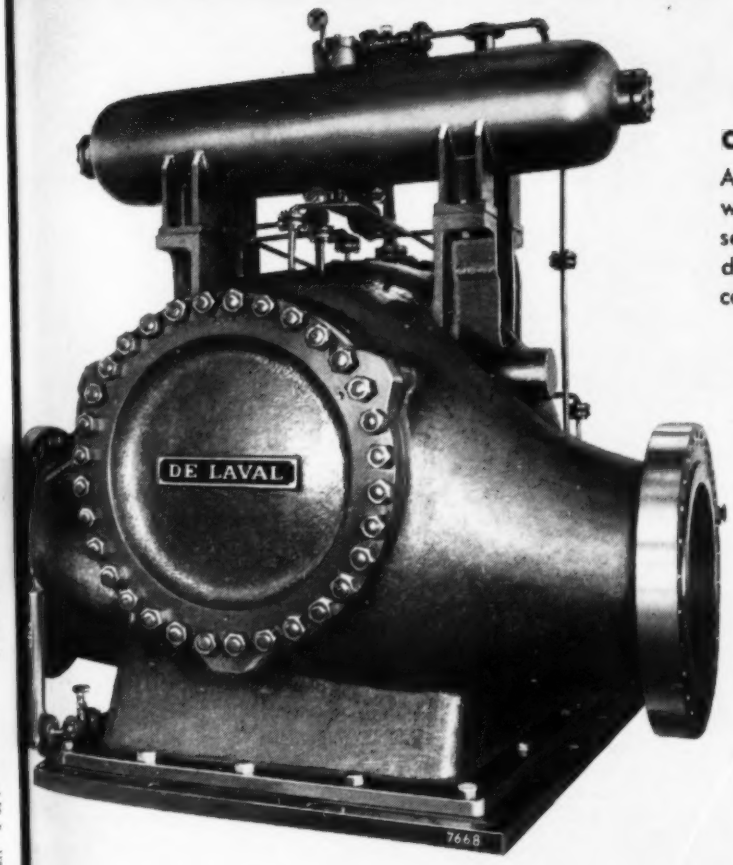
come in two "packages" for easy installation



COMPRESSOR

A De Laval compressor with its emergency seal tank mounted directly on the compressor.

CONSOLE

The console contains the filters, motor-driven pumps, coolers, pressure switches, gauges and other accessories. It eliminates complicated piping on the packaged compressor . . . also serves as a protective cover for the equipment it houses.

Bulletin 503 gives data on De Laval centrifugal pipeline compressors. Write for your copy.

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TOP men . . . TOP papers from API Pipe Line Conference, Houston, May 14-16 . . .

Jennings

Fluid Temperature Rise

A simple test which quickly and accurately determines the condition of engine-driven centrifugal pumps and their operating efficiency. Proven in the field.

G. P. Jennings & L. P. Meade

Page 26

Automatic Measurement

Newberg

With 7 to 8 million barrels of crude and products being measured in pipe line operations each day, automatic control is one of the "hot" topics at any meeting of pipeliners. Improved measuring, sampling and testing devices are being developed continuously. How is the industry accepting these new techniques? Just what does the future hold for the development and application of automatic devices for crude oil measurement?

Atkinson

M. H. Atkinson and A. H. Newberg

Page 30

NATO Pipe Line Systems

Shipley

Here are some of the problems faced by the builders of NATO systems in Europe. Lack of equipment, labor problems and legal regulations complicated the task.

J. R. Shipley

Page 33

Fayman

Electronic Computers

One company has worked out basic solutions to products scheduling problems with an electronic computer research team. Bigger machines for full-scale planning are on the way.

D. L. Fayman

Page 35

Dampening Pulsations

Ludwig

This novel design controls pulsations without use of gas-filled chambers. A description of its engineering features for pipe line applications.

Milton Ludwig

Page 38

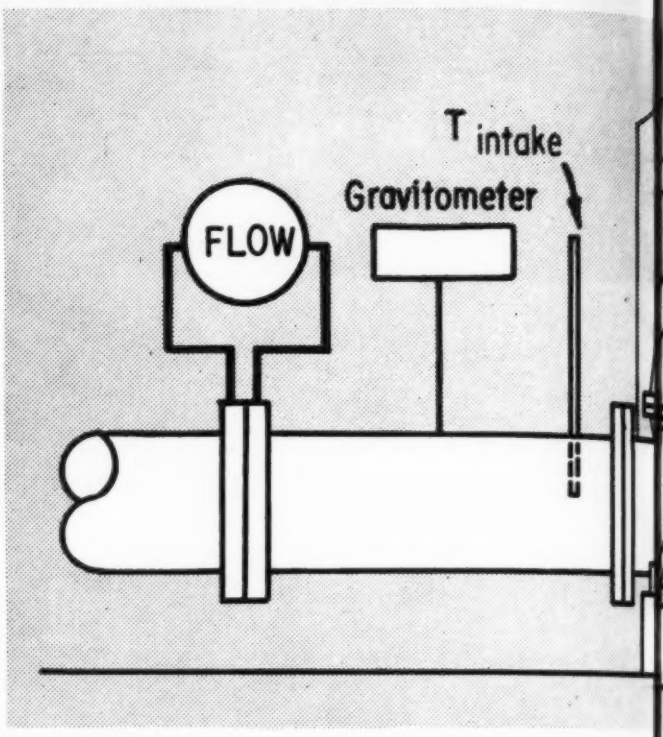


FIGURE 1—Test set-up for determining efficiency of centrifugal pu ity and tem to determine the p es and effici

AN API FEATURE

Fluid Temperature Ris

New method quickly determines power loss and pump efficiency from fluid temperature, gravity, and pressure measurements.

By G. P. JENNINGS, Phillips Pipe Line Company
and L. P. MEADE, Phillips Petroleum Company
Bartlesville, Oklahoma

WITH ELECTRIC MOTOR drives, efficiencies of pipe line pumps can be readily determined, but it is not so easy to check the power losses and efficiency of engine-driven centrifugals. This new method of evaluating power losses in the pump and its efficiency provide accurate information to the operator. As the rotating element wears, efficiency drops and he knows just when losses have reached a point where higher operating costs justify the cost of reconditioning. Temperature rise of the crude or products pumped is the key to the method.

The over-all efficiency of any mechanical unit is defined as the ratio of work output to work input. In the case of a centrifugal pump, the work output is the hydraulic horsepower of the pump, and the work input, or shaft

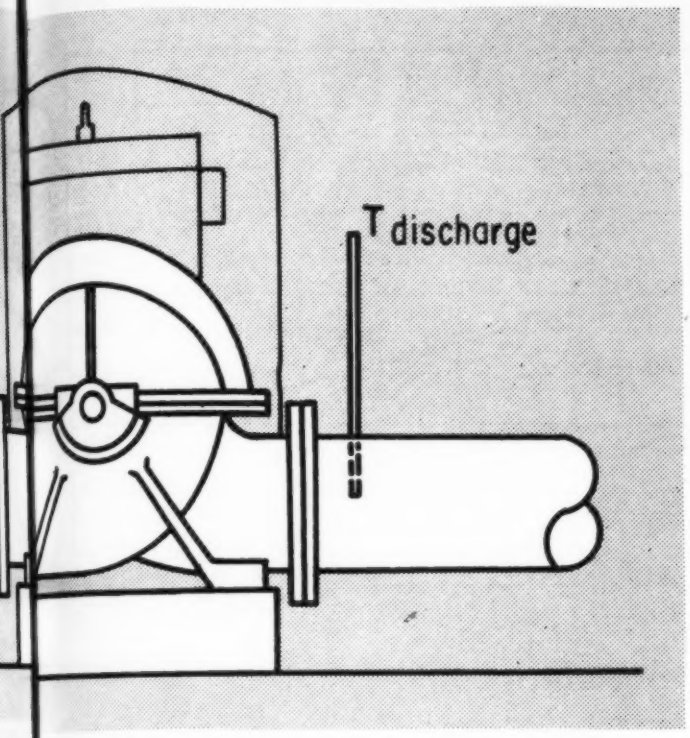
horsepo which can be efficien

Heat C determi made o heat, wh product determi to the tion of manner

Reducing

Where:

hp =
Q =
W =
P =
g =



...ity and temperature rise of fluids through the pump are observed ...es and efficiency.

... Rise = Pump Efficiency

horsepower, is the hydraulic horsepower plus all the losses which occur within the pump. Therefore, if the losses can be determined, it is an easy matter to find the pump efficiency.

Heat Content of Power Losses Determined First. To determine the power losses within the pump, use will be made of the fact that all of the losses are converted to heat, which in turn raises the temperature of the flowing product stream. For an incompressible fluid, an accurate determination of the rise in temperature from the suction to the discharge of a pump makes possible the calculation of horsepower losses and efficiency in the following manner:

$$hp = \frac{(42)\ (2.31)\ QWP}{(1{,}440)\ (33{,}000)g}$$

Reducing:

$$hp = \frac{.00000204\ QWP}{g} \qquad (1)$$

Where:

hp = hydraulic horsepower.
Q = rate of flow, barrels per day at inlet conditions.
W = weight of product, pounds per gallon at inlet conditions.
P = differential pressure, pounds per square inch.
g = specific gravity of product at inlet conditions.

$$L = \frac{42QW\ C_p\ T_1}{(24)\ (2{,}546)} \qquad (2)$$

Where:

L = horsepower losses in pump.
W = weight of product, pounds per gallon at inlet conditions.
C_p = specific heat of product, Btu per pound per degree fahrenheit.
T_1 = temperature rise across pump, degrees fahrenheit.

Then:

$$e = \left(\frac{hp}{hp + L}\right) 100 \qquad (3)$$

Where:

e = efficiency, percent.

Temperature Rise From Compression Must Be Considered, Too. Unfortunately, the problem is not quite this simple for a petroleum product. Apart from the temperature rise caused by the heat equivalent of the power losses, adiabatic compression of a hydrocarbon liquid is accompanied by certain thermodynamic effects which cause the temperature to rise far higher than can be accounted for by the heat equivalent of the mechanical work of compression. For example, the heat equivalent of the work required to compress motor fuel and propane to 1000 pounds for square inch would cause temperature rise of 0.04°F. and 0.2°F., respectively. The actual temperature rise for motor fuel is about 3.0°F., and for propane, about 6.5°F. Obviously the increase in stream temperature caused by compression of the flowing fluid should not be charged to inefficiency, and must be subtracted from the total measured temperature rise, *Tr*, across the pump to determine the temperature rise attributable to pump inefficiency.

To determine accurately the temperature rise due to compression, laboratory tests were made on eight hydrocarbon mixtures which varied in specific gravity from 0.6300 to 0.8434. The tests were made by quickly raising the pressure of each sample and measuring the temperature increase. Fortunately, the temperature rise was a straight line function of pressure rise over the experimental pressure range (0.1500 psi). The results of these tests at a pressure increase of 1000 psi have been correlated against specific gravity at 60°F. (see Figure 1). The temperature rise of compression varies with product temperature, and the data should not be used for temperatures above 110°F. or below 40°F.

To give an idea of the magnitude of the variation in the temperature rise with product temperature, isooctane (2, 2, 4-trimethylpentane) has a temperature rise of 3.02°F. per 1000 psi at 90°F.; at 60°F., the temperature rise is 2.97°F. per 1000 psi. These data can be developed for other temperature ranges, if necessary.

TABLE 1—Temperature rise of compression varies for hydrocarbons of different specific gravity tested.

HYDROCARBON	Sp. Gr.	°F/1000 PSI
26 lb. Natural Gasoline	.6300	4.23
13 lb. Natural Gasoline	.6508	3.75
IsoOctane	.6962	3.02
100 Octane Aviation Gasoline	.7014	3.27
Refinery Base Gasoline	.7249	2.93
Crude Oil	.8150	2.06
Furnace Oil	.8250	2.00
Gas-Oil	.8434	1.87

Specific Gravity Correction Applied. Another factor complicates the determination of the efficiency of a pump handling a highly compressible product, such as propane

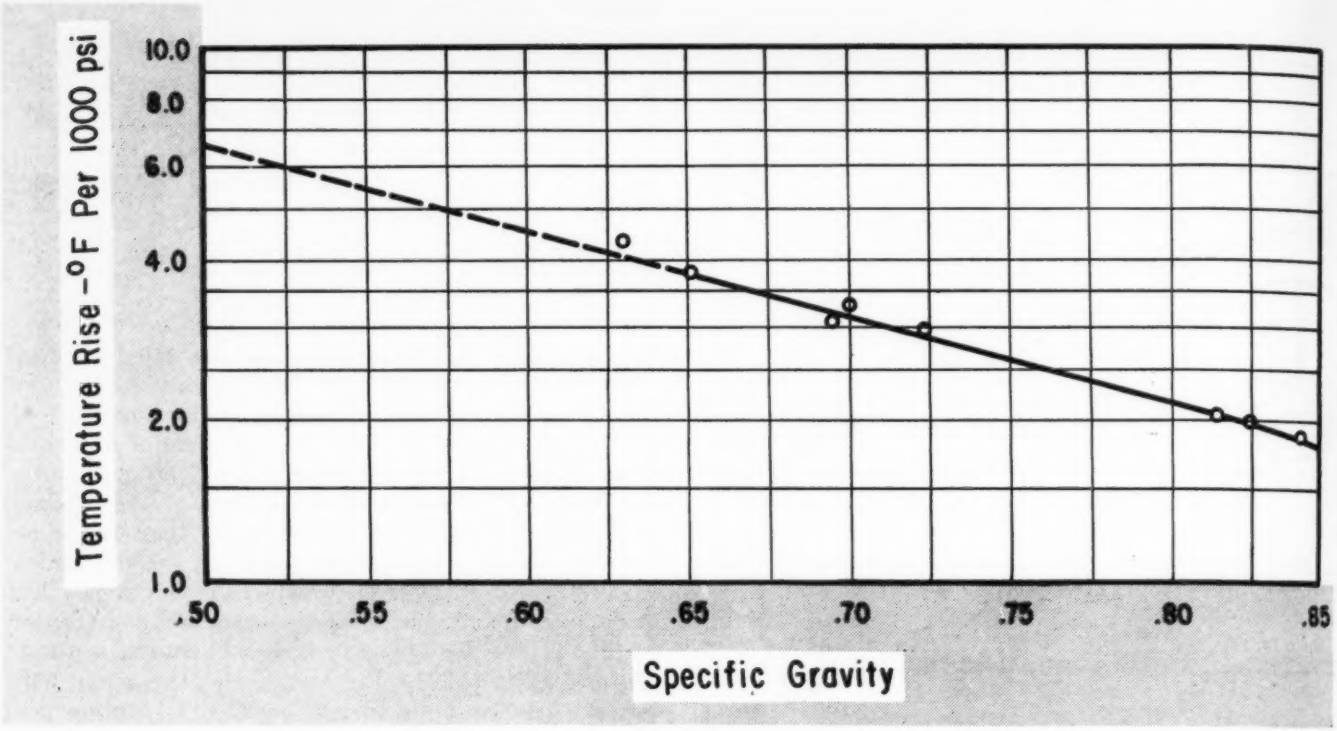


FIGURE 2—Temperature rise of fluids due to adiabatic compression may be closely approximated from this plot of Phillips experimental data.

or butane. The specific gravity at the discharge of the pump is higher than that at the inlet, due to the compression of the product within the pump. When this occurs, use of the measured differential pressure causes the pump efficiency to appear higher than it actually is. A correction term, $\left(1-\frac{a}{2}\right)$ where a is the ratio of the increase in specific gravity through the pump to the specific gravity at the suction, can be introduced to correct for the change in specific gravity.

Making the necessary corrections to equations (1), (2) and (3) to correct for the effects of compressibility, we can derive the equations necessary for determining the efficiencies of centrifugal pumps handling hydrocarbons or other compressible liquids.

Since the total temperature rise across the pump must be corrected for the temperature rise of compression,

$$T_t = T_r - T_c \quad (4)$$

Where:

T_t = net temperature rise for losses, degrees fahrenheit.
T_r = total temperature rise through pump, degrees fahrenheit.
T_c = temperature rise of compression, degrees fahrenheit (fig. 1).

Correcting equation (1) for the change in specific gravity through the pump:

$$hp = \frac{.00000204\,QWP}{g}\left(1-\frac{a}{2}\right) \quad (5)$$

Combining equations (2), (3), (4), and (5), and reducing:

$$e = \left(\frac{\frac{.00000204\,QWP}{g}\left(1-\frac{a}{2}\right)}{\frac{.00000204\,QWP}{g}1-\frac{a}{2}+\frac{QWC_p(T_r-T_c)}{1{,}455}}\right)100 \quad (6)$$

Factoring out Q and W:

$$e = \left(\frac{.00000204\left(\frac{P}{g}\right)\left(1-\frac{a}{2}\right)}{.00000204\left(\frac{P}{g}\right)1-\frac{a}{2}+\frac{C_p\,(T_r-T_c)}{1{,}455}}\right)100 \quad (7)$$

Multiplying by g:

$$e = \left(\frac{.00000204P\left(1-\frac{a}{2}\right)}{.00000204P\left(1-\frac{a}{2}\right)+\frac{gC_p\,(T_r-T_c)}{1{,}455}}\right)100 \quad (8)$$

About the Author

G. P. JENNINGS, superintendent of operations of Phillips Pipe Line Company, presented this paper before the Seventh Annual Pipe Line Conference of the American Petroleum Institute's Division of Transportation in Houston. He was co-author with L. P. Meade, manager of the Development Branch of Phillips Engineering department. Jennings obtained his M.E. degree at Rensselaer Polytechnic Institute in 1923. He served with Worthington Corporation three years as service engineer, and for two years was in the zinc industry as design engineer. He joined Phillips in 1930 as design engineer and has been engaged in products pipe line design, construction and operations for the past 23 years. During 1953-54 he was chief of the products pipe line section for NATO.

Which reduces to:

$$e = \left(\frac{P}{P + \frac{336.6\, g C_p\, (T_r - T_c)}{\left(1 - \frac{a}{2}\right)}} \right) 100 \qquad (9)$$

It should be noted that the pumping rate Q factors out is therefore not needed to determine the pump efficiency. This is quite fortunate because it is often difficult to obtain the exact flow rate at the time of the test.

Although it complicates the equations somewhat, the expression $1 - \left(\frac{a}{2}\right)$ is retained throughout the derivation for the sake of accuracy. As noted above, the term has considerable significance for highly compressible fluids, such as propane and butane, but may be ignored for motor fuels and heavier hydrocarbons. The examples presented later ignore this term.

The specific heat of the liquid, C_p, can be found from Figure 2, which was prepared from correlations of experimental data of the Bureau of Standards. The mean temperature should always be used of the liquid in the pump in determining the specific heat. The API gravity shown in Figure 2, however, should be that at 60°F.

Actual Measurement of Temperature Rise Must Be Done Carefully for Accurate Results. The most difficult and critical part of the procedure is to determine the exact temperature rise of the product through the pump. Thermometer wells can be installed in the piping on the intake and discharge sides of the pump and filled with oil. A glass stem thermometer with 0.1°F. divisions can be used, and read to .05°F. Only one thermometer should be used, moving it from one well to the other after reading, in order to cancel any errors due to stem correction, etc., as temperature difference is the value desired.

With a large capacity, low head pump the net temperature rise, T_1, may be only 1°F. and thus a .05°F. error in reading the temperature rise will result in about 1 percent error in efficiency. However, with a low capacity, high head pump the net set temperature rise, T_1, may be 5°F. and a .05°F. temperature error will cause an error in efficiency of only about 0.2 percent.

Here is How the Method Works. Using the Measured field data:

Product pumped ..... 12-pound natural gasoline.
Gravity, at 60°F..... 84.2 API or 6560 specific gravity.
Pumping rate ..... 28,464 barrels per day.
Pump differential pressure ..... 1207 psi.
Intake temperature ..... 80.10°F.
Discharge temperature ..... 87.55°F.
Temperature Rise ..... 7.45°F.

Calculations:

1. Temperature correction for compressibility: $T_r = 7.45°$ F.

   From Figure 1, $T_c = 3.70°$ F. per 1000 psi.

   $T_c = (3.70)\ (1.207) = 4.46°$ F.

   $T_1 = T_r - T_c = 7.45 - 4.46 = 2.99°$ F. net rise.

2. pump efficiency: $e = \frac{1207}{1207 + (336.6)\ (.6458)\ (.531)\ (2.99)} = 77.8$ percent.

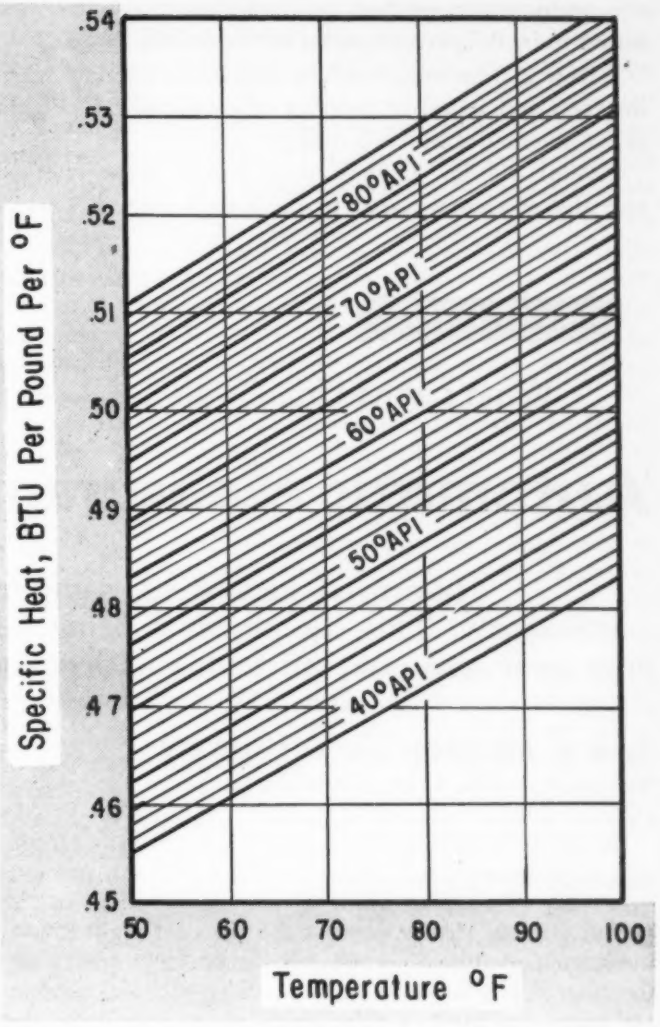


FIGURE 3—Specific heat of petroleum products related to gravity and temperature.

The manufacturer's pump curve showed the efficiency at this rate to be 77.0 percent.

Bearing and Case Losses are Negligible. Usually no allowance need be made for the heat loss from the bearings. With a 300-horsepower ball-bearing pump this is only about one-half hp for both bearings. Furthermore, if the bearings are cooled with the product pumped, the heat loss is accounted for in the calculation.

The heat loss from the pump case even in winter weather is negligible. During the summer there may be a slight gain from the atmosphere, but this is also negligible.

Field Tests Prove Results. Numerous tests have proved the accuracy of the method. A 400-hp electric motor-driven pump was checked by the temperature method on No. 2 distillate and premium gasoline and found to be below the manufacturer's rated efficiency by 9.5 percent and 10.7 percent, respectively. It was then checked with a watt hour meter and found to be 9.2 percent low. The element was inspected and the first stage was found to be badly damaged by some foreign particles. A new element was installed and the efficiency again checked by

the temperature method on housebrand gasoline and found to be 0.7 percent above the rated efficiency.

A new 800-hp engine-driven pump was checked when installed and found to have an efficiency of 0.8 percent above the manufacturer's rating.

Several 300-hp engine-driven pumps were checked and the efficiency found to be 3 to 5 percent low. A routine impeller change brought the efficiency up to the manufacturer's rating or slightly above.

REFERENCE

[1] Anonymous. "Thermal Properties of Petroleum Products," Miscellaneous Publications of Bureau of Standards, No. 97, U. S. Government Printing Office, Washington, D. C. (1929).

ACKNOWLEDGMENT

A paper prepared by G. P. Jennings and L. P. Meade entitled Determination of Pump Efficiencies From Fluid Temperature Rise and presented by the former at the Seventh Annual Pipe Line Conference, API Division of Transportation, Shamrock Hilton Hotel, Houston, May 14, 1956.

AN API FEATURE

What's ahead in . . .

Automatic Measurement of Crude Oil

Improved measuring, sampling, and testing devices are being developed continuously. This equipment is being accepted in pipe line operations in an effort to do a more accurate, efficient, and dependable job.

By M. H. ATKINSON and A. H. NEWBERG
Service Pipe Line Company, Tulsa

SEVEN TO EIGHT MILLION barrels of crude and products are measured and remeasured in pipe line operations every day. The dollar value of these transactions over a period of time greatly exceeds the physical plant investment itself. Automatic control is the hottest topic at any meeting of pipeliners today. And there is a real demand for more attention to the installation, operation and maintenance of measurement devices.

Probably near future trends in measurement practices can be reasonably forecasted on the basis of the tools immediately available. It is possible right now by a combination of existing instruments, automatic controls, and remote transmission systems to remotely control and record at any one or a number of points the whole sequence of custody transfer measurements.

A print-out system of this nature would record automatically the date, tank number, location, gross barrels, temperature, gravity, BS&W content. It would reduce data to net barrels and print out on multicopy teletype, adding machine tape, punch tape or magnetic tape remotely at a central office and wherever else was desired along the way. Only two assumptions are made: that BS&W content and gravity could be obtained with presently developed capacitance type instruments and gravitometers.

If remote control and recording can be made at the receiving end, it can feasibly be turned around and made to work at the delivery point or for that matter at any of the exchange or transfer points in between. While these results are possible now, their accomplishment is some

Strong incentives are already appearing for wider use of positive displacement meters . . .

1. **Large diameter pipe lines with greatly increased throughput bring need for decreasing rather than adding to existing tankage to relieve congestion, equate costs and improve handling and operational control.**
2. **Satisfactory high-capacity meters have been developed and the required proving procedures are being worked out, now.**
3. **Meters of all sizes have been greatly improved in recent years by the use of better materials, bearings, and advanced measuring element design permitting higher capacities with less turbulence and wear from entrained foreign materials through streamlined chambers.**
4. **Notable advances are being made in read-out and control systems. It is now possible to get an infinite variety of readings and print-out locally and remotely with automatic control from multiple meter batteries, combining or subtracting as desired.**

time in the future. These possibilities represent the limits of reasonable future trends as we can see them now.

Positive Displacement Meters. Meters have been used widely in products service and not nearly so widely for crude oil. The products people were forced to their use, and having to live with them they learned to make them work. Their meters operate satisfactorily because installations are carefully designed and are properly installed, operated, proved, and maintained. They know well what it costs in time and money to make a meter work because of the incentives involved. The crude oil industry on the other hand probably got off to a bad start in use of meters. There was always an acceptable alternative in hand gaging of a less volatile product that could be readily read on a steel tape.

I see no valid reason either from my own or other industries' and manufacturers' experiences why meters will not work equally as well in crude oil as in products with comparable accuracies. Factors of product difference tend to cancel out. If on the one hand products are cleaner and of uniform viscosity, crude has better lubricating qualities.

Meter accuracy and dependability have been proved by years of service in products systems. But if you use them, be willing to accept the responsibility of carefully designing the installation and properly operating, proving and maintaining them after they are installed. Failure to do so will result in a poor installation and unsatisfactory measurements.

Automatic Sampling Devices. Automatic sampling of crude oil has been used for years for custody transfer purposes. It has been estimated that as high as 40 to 50 percent of all crude oil custody transfers and exchanges are made by automatic samplers. They have been used more extensively than any of the other automatic devices for strictly custody transfer purposes. Everyone seems to agree that automatic line samples are more representative than tank samples. This willingness to use them despite their mechanical difficulties is the reason they have been made to work.

Actually, automatic sampling of crude oil has been extremely difficult by the nature of crude oil and the effects of lowering line and atmospheric temperatures on its components. The problem resolves itself into two phases. The first phase had to do with making straight constant rate type samplers that would work with different kinds of crude under varying conditions of temperature and, in some cases, pressure. Also operating personnel must be trained to maintain them and not neglect them as being of no importance.

The second phase is concerned more with the factors involved in obtaining a truly representative sample than in workable samplers since this problem has been at least partly solved. Manufacturers are now alert to the inherent difficulties of crude oil sampling and are producing samplers which will work successfully in crude oil service. Most of these samplers are constant rate, and attention is now focusing on proportional rate samplers.

Pipe Line Engineers Look for Answers to Sampling Problems. Crude oil is nonhomogeneous and contains varying amounts of BS&W, which are not distributed uniformly through the moving stream. Several questions arise.

- What are the minimum velocities and turbulence necessary for uniform mixing?
- What is the proper type of sampling tap and where should it be located?
- Should a portion of the stream be externally circulated or bypassed by or through the sampling device?
- How much must the flow rate change before a flow responsive type sampler is required?

Answers will be found out to these problems — should not discourage the use of automatic samplers because the results obtained now are more representative than can be secured by manual methods.

Automatic samplers are definitely in the measurement picture and they should continue to be used with full confidence. However they are and may continue to be a critical installation. Considerable care should be used in their selection and operation.

Improved Automatic Tank Gages Offer Promise. Both direct and remote reading automatic tank gages of known accuracy are acceptable for custody transfer. Up to the present time they have not had wide industry acceptance for strictly custody transfer purposes for a variety of reasons. The principal reason is that maintenance costs tend to exceed the costs required for manual gaging. In the absence of automatic temperature devices and samplers which would keep men off tanks, they might as well take a hand gage at the same time. This is particularly true of large tankage at terminal and delivery facilities where there is usually available manpower and labor costs are not a critical factor.

On the other hand labor costs are a critical factor on smaller field gathering and lease tanks because of dispersal and more rapid tank turnover. Here the impetus is towards semi- and full-automatic operation and automatic tank gages are being used. They also have an exclusive field in either area of application where highly volatile or dangerous liquids have to be handled. Whatever

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ARTHUR H. NEWBERG joined Service Pipe Line Company in 1945 as senior office engineer and was appointed chief engineer in 1947. During World War II he worked in various capacities for the Office Engineering Division of the Panama Canal and the Williams Brothers Corporation on the design of pipe line facilities for the armed forces underground oil storage program. A graduate of the University of Nebraska, Newberg did graduate work at Washington University. He is a registered professional engineer in several states and has been active in API activities, as well as in other professional associations.

their use in custody transfer, they are the most widely used of the automatic devices for intracompany measurement, particularly in conjunction with improved remote transmission systems permitting dependable local and distance transmission at economic costs.

There have been marked improvements in both the basic mechanical gage and particularly in the remote transmitting components since their inclusion in API Standard 2500. The most notable improvement in the mechanical gage has been in the counterweight mechanism. The older weight type has been replaced with the better constant tension coiled spring or improved motors. With this has gone other improvements in reading facilities, tapes, pulleys, and float or sensing mechanisms. These improvements are reflected in better gage performance and reliability. The remote transmitting systems as previously mentioned now include revisions in design which permit feasible long distance as well as local transmission.

Automatic tank gages are and can be used for custody transfer if properly designed, installed, and maintained. Outside factors influencing their use are part of the over-all measurement problem and will continue to have to be resolved on the local level. Some objections to their use will be removed when basic accuracy and repeatability can be established independent of hand line comparison and calibration procedure.

There Is Need for a Simpler, Less Expensive Means of Measuring Temperature Automatically. A variety of automatic temperature devices are permissible for custody transfer. Their accuracy and dependability have not been seriously questioned, but their use has been restricted by limitations in measuring means as to areas of application and specific need. They are needed and are used on the smaller, fixed roof, lease and field gathering tanks where the trend is towards semi- and full-automatic operation. For these installations the types other than electric resistance are used.

On larger tanks, other types could also be used on fixed roofs, although not conveniently due to tank height. On floating roofs only the averaging resistance type can be used. These installations are expensive and probably cannot be justified except where the manual method is not thought to be representative, or large vapor losses and product downgrading results. These services would be with low gravity, heated and blending stocks, highly volatile or poisonous gas from produced liquids such as sour crudes. Certainly the need exists for a simpler, less expensive type of automatic temperature device, particularly for large capacity tanks.

Better Capacitance Instruments for BS&W and Gravity Measurement Could Change Industry's Method of Inventory and Control. These instruments at their present stage of development offer at least the possibility of an automatic device for the determination of BS&W and maybe gravity. Associated with them are other instruments also for measuring gravity and viscosity, Reid vapor pressure, and other properties. If an instrument or instruments could be perfected for acceptable determination of BS&W and gravity, they would remove the need for most sampling and testing in crude oil measurement. BS&W is the critical measurement; once this is solved, the others will follow as a matter of course.

Acceptance of these determinations by methods other than sampling and testing involves much more than perfecting the instruments themselves. It could change the whole industry's method of inventory and control. An increasing number of this class of instruments is being installed, tried, and used. Over a period of time their continued use should provide an answer on a comparative basis which will not be disruptive to the industry.

Manual Measurement Weaknesses and Economics Boost Automatic Controls. The measurement inaccuracies and shortcomings of the manual methods of making custody transfer or exchange are prime factors in the development and application of automatic devices. The pipe line industry has been trying to find a solution to this problem. At the same time they were faced with a continuing upward demand for increases in handling capacity and product refinement. The total of these forces was to make the problem more acute because the point is reached in multiplicity of operation and process control where the human being is no longer the most efficient and economical means available. In fact, his labor finally becomes prohibitive except in a supervisory control position.

Emphasis upon the automatic devices was reflected in development and codification (approval for custody transfer purposes) of positive displacement meters, automatic samplers, automatic tank gages, and automatic temperature devices, in about that order. Positive displacement meters are covered by the Joint ASME-API Code 1101. Automatic samplers were approved in both the older API Code 25 and in the newer Standard 2500, and a new revision to this standard covering automatic samplers in greater detail is under consideration. Automatic tank gage and temperature devices were included as revisions in the new issue of Standard 2500.

Use of these devices provide acceptable alternatives for the manual methods with greater accuracy and flexibility, and are not dependent upon the human element except for reading and control. They must, however, be properly installed, operated, and maintained. Their use also controls more efficiently the other objections to the manual method having to do with conservation loss and control, reduction of fire hazard, loss of human life, and the mounting costs of labor.

An associate development of automatic devices has been their accompanying remote transmission systems. It is possible to remotely transmit any or all of these instrument readings with the exception of those obtained by sampling and testing. Full utilization of this aspect of the use of automatic devices will be held up at least partly until testing results can be finally obtained and transmitted as straight instrument readings. Remote transmitted readings have code acceptance if mutually agreeable to the contracting parties.

It is interesting to note that much of the impetus for enlarging and perfecting remote transmission equipment came from the noncustody transfer use of these and similar devices used in intracompany operations. It should also be noted that intracompany operation accounts for actually a greater use of these instruments than custody transfer, if automatic sampling is excluded. Inferential flow measuring devices would have to be included as an important addition to this group when used for this purpose.

It was inevitable that sooner or later these components

would be combined into a single system for automatic control of all the operations involved in making a custody transfer. This has taken place in the emergence of automatic lease custody transfer. This system which will, with unattended operation, automatically tender oil from the producing field to a receiving pipeline is receiving serious consideration and a number of experimental and trial installations have already been made. If these installations are successful, and there is every reason to believe they will be, this type of controlled transfer will receive industry acceptance and eventual standardization.

The oil industry is now in the interim period between the use of manual methods and the adoption of automatic devices. It has also seen the development of a workable automatic custody transfer control system.

Industry Acceptance and Personnel Are Next Major Goals. With these advanced measurement techniques available, it would seem that all companies would take advantage of their use. The fact remains, however, that technological change is a slow process when normal economic forces are in action. The oil industry must first satisfy itself that use of such devices will result in measurement costs in proper proportion to the improved accuracy and lost control obtained. It has a large investment in manual measurement equipment and in personnel trained to their use. From an industry standpoint it is perhaps better if this transition takes place slowly as existing equipment becomes obsolete and personnel is changed or retires. Various regulatory and inspection bodies must also approve major changes in field practice to assure protection of the public interest.

This requires education and demonstration by individual operators that automatic devices equal or exceed manual measurement accuracy. If industry does not accept this responsibility, there is a very good possibility that the limitations of the equipment will not be realized and therefore they will never be properly utilized. In some applications this could mean reduced rather than improved measurement accuracy. This happens more often than is generally realized. While operational changes in custody transfer measurement procedures and techniques should change slowly and in an orderly manner for the majority of the industry, it should also have available data and experience with advanced methods. It should also strive to improve existing methods and develop new ones. All of these objectives are being accomplished by research and development, both within the industry and by the associated equipment manufacturers.

ACKNOWLEDGMENT

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AN API FEATURE

Unique Problems on NATO Pipe Lines

Construction problems, legal restrictions, and national boundary crossings complicate operations. But the 4500-mile system promises to be a vital defense link for 15 countries.

By J. R. SHIPLEY
Sohio Pipe Line Company
St. Louis

AN EXTENSIVE pipe line network is under construction in Europe to supply fuels to air fields and military installations. Difficulties arise from differences in bidding regulations among various member countries, inadequate equipment and experience of native contractors, lack of laws and regulations for governing the lines, and many national boundary crossings.

A 4500-mile system now is authorized. The next big problem facing NATO is the creation of a trained operating organization.

The North Atlantic Treaty was signed by 12 countries April 4, 1949. This treaty was made to maintain international peace and security and to promote stability and well-being in the North Atlantic area. The treaty is essentially for military defense.

In February, 1952, Greece and Turkey became members, and in 1955 the Federal Republic of Western Germany became a member. The present 15 member governments are Belgium, Canada, Denmark, France, Western Germany, Iceland, Italy, Luxembourg, the Netherlands, Norway, Portugal, the United Kingdom, and the U. S.

To carry out the defense objectives, a common infrastructure was set up by NATO. Infrastructure is a generic term to denote the basic fixed military installations necessary for support and efficient use of military forces; and consists of airfields, signal communications, military headquarters, pipe lines and terminals, radar-warning and navigational-aid stations, port installations, etc.

Common infrastructure are those installations requested by SHAPE for maintenance and training of NATO international forces in time of peace and for their effective operation in time of war, and are paid for collectively by member governments. The proportion of the total cost paid by each country is fixed by agreement.

Because of the increasing problem of logistic support

for the airfields being constructed (96 were authorized by 1952), the military recommended in 1952 that a pipe line system be constructed to supply them. A group of experts were called together to develop standards and establish estimating unit costs for such a system. Based on the conclusions reached by this group, an initial system was recommended to and approved by the Council in December, 1952.

Although the system originally was contemplated for airfield support only, it soon became apparent that it would be an excellent logistic support system for motor vehicles, also. So the designs were modified where necessary in order for the system to handle two products.

New NATO staff sections set up for pipe lines. The decision to construct a pipe line system created a need for a new staff section at NATO staff headquarters. This section was formed and named the POL Section.

The name is derived from that given by the United Kingdom to petroleum branches and means the Petrol, Oils, and Lubricant Section; however, its function in NATO is to handle only pipe lines and terminals.

The construction of product pipe lines in Europe immediately created an organization and manning problem. With the exception of a short product system in France which had been built since 1951, construction of a military system during World War II in the United Kingdom, and construction of several gas lines, there had been no pipe line construction in Europe. Consequently, there were practically no personnel in Europe experienced in design, construction, or operation.

In practically all countries it was necessary to create a new organization to handle the projects. The plan used varied in the member countries.

In some countries separate bureaus were created to handle all problems and were manned by recruits from oil companies in those countries. In other countries separate small bureaus for control were formed with the actual design and supervision of construction contracted to consulting engineering firms (called architect-engineers or A.E.'s for short in Europe). Practically all of the bureaus were attached to military departments.

These organization plans still left a problem of obtaining experienced personnel. In general they were unavailable in sufficient number, and, consequently, there was a long delay in starting the actual program while the necessary personnel was trained sufficiently so that final plans could be made.

To assist in this problem, the NATO international staff issued many plans and documents setting forth policy for guidance in design and construction. These consisted of typical pump-station plans, tank plans, terminal layouts, and manifold plans, specifications for construction of these units as well as for pipe line construction, and documents on testing of lines, cutting of batches, corrosion protection, etc. All of these documents and plans were approved and issued by the Infrastructure Committee.

Also all host countries have been supplied with the *API Tentative Bulletin 1105: Bulletin on Construction Practices for Oil and Products Pipe Lines;* and the *API Tentative Standard 1104: Standard for Field Welding of Pipe Lines.*

Many field trips were made by the members of the POL Section to host countries to help select sites and routes for lines and terminals and to advise in preparing the plans.

Conventional design for lines and stations. The pipe line construction recommended was of simple, straight-forward design using Grade B line pipe. The coating is one coat of enamel reinforced with either one layer of felt or glass fiber wrap.

The pumping-station design adopted as standard consists of multistage centrifugal pumps driven through speed increasers by diesel engines and operating in series. The pumping units are designed for portability so that they can be moved where needed.

The units are housed in blast-proof reinforced concrete buildings. The control system is of the primary type for protection of the line and major functions of the pumping unit.

All of the designs were based on minimum capital cost to meet the military requirement without regard to operating costs. This results in a minimum size line and a maximum number of pumping stations, and for flexibility results in all stations being multiunit.

The system, because of need for flexibility, has quite a few junction points where products can be diverted through alternate routes to destination. These junction points and the military requirement for dispersion created some difficult problems in design.

After considerable delay, plans and cost estimates for projects started flowing into the Infrastructure Payments and Progress Committee for approval.

Unusual problems faced in implementing the pipe line system. The problem of procuring material is a major item. NATO had agreed that all material purchased was subject to international competitive bidding for all member countries. There are differences in specifying material, contractual terms, custom regulations, and taxes between the various host countries. This resulted in considerable delay in placing orders because such problems had to be resolved and approved by NATO.

The same problems existed in awarding construction contracts. In some parts of the system the military requirement for maximum standardization caused additional difficulties because several countries would have to purchase the same material at the same time under agreed conditions.

The system for bidding, although streamlined as far as possible, is still time-consuming and is doubly so when several countries are involved simultaneously.

Contractors lacked equipment for some jobs. Construction of the pipe lines raised many problems. With the exception of a few companies, there were no contractors equipped with pipe-laying equipment as we know it. Most of the contractors had some bulldozers but no sideboom tractors, bending machines, coating machines, road-boring machines, and for that matter, no line-up clamps.

However, because of the need for constructing the lines and the apparent lack of interest on the part of experienced foreign contractors in most projects, it was necessary to proceed with awarding contracts on the best price.

This led to many strange practices in construction; e.g., on one job, instead of skids, metal chairs of uniform

height were used to support the pipe for welding. A crew lined up the pipe by digging under the chairs for each section. The rate of construction was slow but the results were satisfactory.

On another job no line-up clamps were used. Each section was aligned and braced and all other operations were stopped until the joint was welded.

In general, under these conditions, mill coated pipe was used inasmuch as coating machines were unavailable. Pipe bends usually were factory made from measurements taken in the field. In countries with large level areas and a considerable number of drainage ditches, it was found cheaper to ditch to eliminate bends than to have them made. Ditching machines were generally the ladder type.

Over-the-front boom tractors were used in lieu of sideboom tractors, with a great deal of the pipe-handling work done by hand. The welding on most jobs was done "up hill." There were very few "down hand" welders available.

On one job where the contractor had sufficient equipment, he found after a few days that it was cheaper to dispense with the equipment and use manpower for most operations except coating.

It must be said that in several countries regular pipe line construction equipment and methods, as we know them, are used and progress of construction has been satisfactory and three to four times faster.

Unusual legal restrictions created problems. Another of the problems that was encountered was the lack of laws and regulations for pipe lines. This resulted in some delay and, in some cases, some very restrictive regulations for rail, road, and water-course crossings.

One country requires the casing under roads and railroads to be filled with sand after the pipe is laid. In another country the laws do not allow common labor to be transported from their district, which results in the contractors having to discharge all of their unskilled labor and rehiring new labor about every six miles of line.

Inasmuch as most rivers are navigable and are used heavily by barges, the depth of pipe below streambed is great. Also, along canals, quite impressive construction methods are required to insure that no water is lost in making a crossing.

About the Author

J. R. SHIPLEY, from September, 1954, to January, 1956, was head of the POL Section of the NATO International Staff in Paris. He has now resumed his duties as vice president of Sohio Pipe Line Company, and is assistant to the manager of the Transportation department. He was graduated from the University of Kansas in civil engineering. Prior to joining Sohio Pipe Line in 1944, he worked with the Kansas State Highway Commission, Phillips Petroleum Company and Standard Oil Company of Ohio.

Construction of terminals is relatively simple inasmuch as most countries have had experience in tank construction and have excellent craftsmen in concrete construction. The major difficulty was in laying out manifolds to give the correct flexibility for pipe line operations.

The fact that many of the lines crossed national boundaries has created a problem for customs regulation which is under study.

In face of these difficulties, progress is being made in the construction of a complex pipe line system for NATO with an approved total of approximately 4500 miles to date.

Training operating personnel are next big need. The major problem now facing NATO and the host countries is the organization, manning and training of a competent operating organization. This problem passed its first hurdle late last year in the approval by NATO of the proposed organization plan.

Inasmuch as the initial problem of getting construction started has been solved, it is believed the operating problem will be solved satisfactorily.

It appears that when the NATO pipe line system is completed, it will be one of the best logistic support systems for fuels ever constructed.

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AN API FEATURE

Computers Speed Products Scheduling

Great Lakes research team now quickly calculates a projected 28-day schedule in fraction of time required by manual engineering methods.

By D. L. FAYMAN
Great Lakes Pipe Line Company
Kansas City, Missouri

ELECTRONIC COMPUTERS are proving a useful tool for products pipe line scheduling.

A high speed computer can simulate the physical pipe line system and provide a proving ground for proposed schedules. It allows the scheduling department to test modes of operation which might not be attempted on the actual system. The computer makes rapid mathematical analysis of the network to evaluate operating practices and management policies.

In the summer of 1954, the research staff at Great

Lakes Pipe Line Company began plans for simulating a pipe line on a high speed computer. To assist in the development of this idea, company management provided research personnel, trained at company expense, and rented a medium sized computer. Cost of the project has been $125,700 for the 4½ years of study, including early development work.

Great Lakes' system consists of one network composed of 52 line segments, 15 terminal points and 4 delivery points. Transit tankage and terminal tankage exist in varying amounts at the junction of each line segment. With few exceptions, the terminals are located at the junction of several line segments. About ten distinct products on the average are transported.

This network provides service required of any common carrier, and in addition, provides warehousing and dispensing service at terminal points.

Operating objectives of the system are well defined. Within boundaries of the existing tariff, the system must transport products from any entry point to destination with a minimum of delay and provide adequate facilities for storage and removal of products by owners or their assigns. Products cannot be contaminated or otherwise spoiled during transit or delivery. All of these objectives must be accomplished with a minimum cost and with maximum utilization of capital investment.

Scheduling is key to products system operations. Assuming that a pipe line network is well engineered and properly operated, its efficiency in accomplishing assigned objectives is primarily a function of scheduling. With the "poorest possible" scheduling an otherwise adequate pipe line system might tend to violate its reason for existence. "Optimum" scheduling, on the other hand, would mean virtually ideal service with maximum profit to the owners.

"Poorest possible" scheduling and "optimum" scheduling are not easily defined. Practical operating schedules fall somewhere between these wide limits.

At present, no satisfactory definition of optimum scheduling exists. This would imply ability to compare pairs of similar schedules and consistently choose the best, which by present analytical methods is very difficult.

Rough comparisons now are believed possible. Perhaps within a few years highly accurate determinations will be feasible. When this is possible, proposed schedules for any network can be evaluated and compared with optimum network performance.

It might seem foolhardy to attempt to develop schedules near optimum when even the objective is not defined clearly. However, schedules have been produced for years lacking such a definition and it was felt that a search for a better method would produce useful information.

In 1952, a research program was initiated to explore the feasibility of using high speed computing equipment to produce improved schedules. Fundamental work of defining the problem in terms of mathematics was undertaken by the Midwest Research Institute. This has served as a foundation for succeeding efforts toward automatic scheduling.

This work established the fact that although many pipe line operations may be defined in the form of equations, the more important areas of scheduling defy such definition. These important aspects would not yield to analysis.

To simplify the problem several methods have been

Complexity of the Great Lakes Pipe Line system led to use of an electronic computer for products scheduling. An average of ten different kinds of products move through its 52 segments, from four delivery points to 15 terminals and additional take-off points.

tried. The most promising involves the pumping of predetermined sequence over every scheduling period. It now is being investigated further.

Close cooperation between pipe line engineers and outside research is essential. When solutions are required to problems which have not yielded to normal analysis techniques, decision to use high speed electronic equipment may be a complex one. Problems often yield to mathematical analysis only as a result of concentrated academic interest with adequate economic support to uncover their solutions.

Outside assistance then is needed by the pipe line company research team. And it is available from outside research facilities, company operating personnel and research and development facilities offered by equipment manufacturers. Combined efforts of company researchers and consulting scientists have turned out to be a good combination.

Company personnel must be trained to work with computers. At the start of the computer program it is difficult to find trained persons to handle the analytical problems met. And it is essential that experienced computer people set up the analytical procedures.

Great Lakes has adopted the policy of training qualified and interested employes in techniques of computers to have the right personnel available to conduct this re-

search. The computer research staff works in an atmosphere relatively free from undue pressures common to business. There is usually freedom of time to develop promising ideas. This approach to computer application research is felt to have very likely hastened success of the project.

How the pipe line network is considered. First, scheduling is defined as the attempt to predict the future status of a pipe line system resulting from the current status and to use this information to influence current decisions regarding shipping dates, proposed grades and volumes of movements, and proposed pumping schedules.

The pipe line system is considered to be of one or more pipe line networks. Each network consists of one or more line segments. The line segment is considered to be the elemental unit of any pipe line system. Each segment has the following properties:

1. Input facilities
2. Pumping capacity
3. Line fill
4. Output facilities

When one or more line segments are interconnected in such a way that each segment is dependent on every other segment, basic requirement of a network is satisfied. It follows that networks are independent of all other networks, and thus may be scheduled separately. Individual networks of line segments always contain input points and delivery points and, in some cases, terminal points.

Delivery points accept products at the normal line pumping rate while products are dispensed from a terminal at a rate which differs appreciably from the line pumping rate. Terminals, therefore, have large product storage facilities while delivery points normally require little tankage.

Input points may have tank storage, and always will have pumping ability. At connecting points, transit tankage sometimes is provided. Here it gives sufficient storage to allow two line segments of unlike pumping capacity to match up over a short interval of time. All individual storage tanks, either transit or terminal, are used to service in a single grade for considerable periods of time.

These factors are important to the computer researchers who may not be familiar with product pipe line operations.

Management's active support is vital. Great Lakes management felt that production of better schedules for the pipe line network could mean the difference between an up-to-date and efficient system and one which could become obsolete in the future.

One of the first steps in the program was to convert the basic conceptions of simulating technique to detailed language of the numeric computer. During a period of 18 months, several complete coding efforts for the computer were scrapped and started again. With each there was an improvement.

Early this year, a demonstration of the technique was presented to company management. This involved development of a high speed schedule of a 28-day projected period for one large segment of the network. It was not impractical to attempt full scale network schedules with the small computer used, but the results confirmed the feasibility of the method.

Next, a study was begun to determine the computer best suited to the job of full scale scheduling. Recommendations were presented to management and an order was placed for a much larger and faster machine.

The staff now is converting the latest coding system for the small computer to the language of the larger computer. At the same time, the model is being expanded to simulate transit tankage at the junction points better and to account for variability of the exact system structure better. This is important because the construction department continuously is adding new segments to the network and could in time make a rigid simulating model obsolete.

The larger computer is due for installation in October this year. Allowing two months for a shakedown on both equipment and new machine codes, plans call for full-scale operation by the end of the year.

The high speed simulator is felt to be the most promising approach to automatic scheduling thus far encountered, but it is not a complete solution. There still remains the job of defining the scheduling process mathematically, and it is not an easy one. It is a subject for future research.

What does the product scheduling study cost? This research project has covered a period of nearly 4½ years and has cost $125,700. It is broken down as follows:

Midwest Research Institute fees	$ 22,700
Salaries	27,000
Computer rental	67,400
Office rental	4,400
Training and conference trips	2,500
Office equipment, books and journals	1,700
	$125,700

The new computing instrument and two pieces of auxiliary punch card equipment will be rented at an annual cost of $86,500. There will be increased costs incidental to use of this computer. They will arise from additional personnel and floor space required. Amounts of these costs have not as yet been determined.

These expenditures are expected to be justified by greatly improved service to shippers that will result from daily production of 28-day advance schedules. These schedules should provide shippers with unprecedented control over their product stock picture.

It is anticipated, of course, that with these schedules the pipe line system will be operated at a higher level of efficiency than ever before.

ACKNOWLEDGMENT

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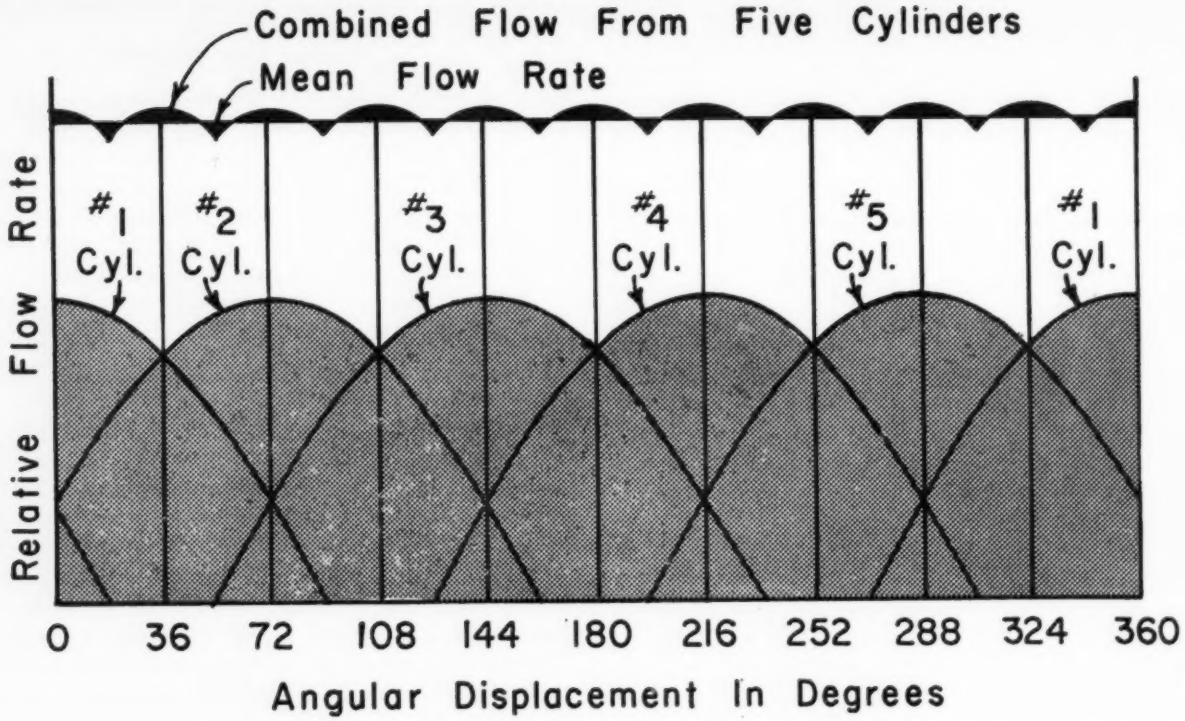


FIGURE 1—Idealized flow from a 5-cylinder single acting pump. Under assumed ideal conditions, each piston would follow a simple sinusoidal motion. Valve leakage, liquid compressibility, and other factors that reduce volumetric efficiency are ignored.

AN API FEATURE

Dampening High-Speed Pump Pulsations

Novel design controls pulsations without use of gas-filled chambers. Here is a description of its engineering features for pipe line applications.

By MILTON LUDWIG
Standard Oil Company of California, San Francisco

ALTHOUGH CRUDE OIL and products are virtually incompressible, it is possible to use their limited compressibility within a surge chamber of practical size to control pulsations. No gas-filled chamber is required. The liquid-filled discharge surge chamber and a reduced-diameter choke tube connected to the pipe line absorb the pulsating component of flow. Installations have been proved in several field installations.

The curves of Figure 1 illustrate approximately the flow variation from a five-cylinder single-acting pump. The picture is idealized to the extent that each piston is assumed to follow a simple sinusoidal motion—which would require an infinitely long connecting rod. No allowance is made for valve leakage, liquid compressibility or other factors that make the volumetric efficiency of the pump less than 100 percent. The effect of a volumetric efficiency of 97 percent, for example, can be roughly treated as a series of flow pulses, each having a magnitude equal to 3 percent of the volume of one cylinder. Pulse frequency is equal to the pump-stroke frequency. Lower frequency components are possible if the behavior of all cylinders is not identical. For example, a reduced volumetric efficiency for a single cylinder will generate a pulsating flow with a fundamental frequency equal to the pump rotative speed. Such possible abnormal conditions must be considered in pulsation dampener design.

Consider the flow variation for the idealized case of Figure 1.

Each cylinder acts as a half-wave rectifier so the mean flow rate from each single-acting cylinder is $1/\pi$ times

the peak flow rate, and the mean flow rate from 5 cylinders is $5/\pi$ (or 1.59155) times the peak flow rate from one cylinder. By reference to Figure 1 and a table of trigonometric functions, it can be shown that the peak instantaneous flow rate is 1.66 percent above the mean rate, and the minimum rate is 3.31 percent below the mean rate. Of more interest for the present purpose is the actual volume excess or deficiency while the flow rate is above or below the mean. A mathematical integration yields the result that the excess, or deficiency, is only 0.00320 times the volume of one cylinder.

This idealized volume excess, or deficiency, is about one-tenth the approximate volume deficiency for an actual pump with a volumetric efficiency of 97 percent. Also note that, for the idealized case, there are 10 flow pulses per revolution, whereas for an actual pump with less than 100 percent volumetric efficiency there will be five major flow pulses per revolution. Thus, a pulsation dampener for a 5-cylinder single-acting pump should be designed for a fundamental frequency of five cycles per revolution.

Now, consider the pressure rise in a liquid-filled surge chamber that must absorb a sudden flow pulse. Assume that the pump has five 4-inch diameter plungers with a 4-inch stroke. The displacement per stroke is 50 cubic inches and 3 percent of this is 1.5 cubic inches. Volume of the surge chamber is 10 cubic feet, or 17,280 cubic inches. The bulk modulus of elasticity is around 180,000 psi, but the effective modulus may be taken as around 150,000 psi to include an allowance for the elasticity of the steel chamber itself .The pressure rise in the chamber for a sudden flow pulse of 1.5 cubic inches would then be:

$$\frac{1.5 \times 150{,}000}{17{,}280} = 13 \text{ psi.}$$

A pressure fluctuation of this magnitude would normally be tolerable at the pump discharge, or suction, but might be highly objectionable if allowed to travel into the discharge or suction piping where it could cause objectionable pipe vibration, especially if the piping layout were such as to permit the generation of resonant pulsations that might, at certain points in the piping system, greatly exceed the pressure pulsation at the pump.

The next requirement for a complete pulsation dampener is, therefore, an element that will keep the pulsations within the liquid-filled chamber. This is the "choke" tube—a length of pipe of relatively small diameter that carries the flow from the surge chamber to the main station discharge header. (Again, note that the design applies equally well to the suction piping.) The cross-sectional area of this tube is made small enough for fluid inertia to offer effective resistance—or more properly, impedance—to cyclic flow changes. The smaller the tube, the greater is the required acceleration for a given change of volume flow rate. The tube must, however, be large enough to pass the steady component of flow with only a moderate pressure loss.

Mathematical analysis is basis for dampener design—The mathematical analysis of a pump pulsation dampener, or surge filter, is analogous to that of an electrical filter in which a condenser is equivalent to the surge chamber and an inductance is equivalent to the choke tube. The characteristics of the system beyond the choke tube must also be considered. A simple case is that of a pump discharging directly into a long oil transmission line. Those familiar with water-hammer calculations will recall that the change of pressure in a particular line is directly proportional to the change of flow rate and, by analogy with the long electrical transmission line, the constant of proportionability may be defined as the characteristic, or surge, impedance of the line. The surge impedance for the pipeline is a pure resistance since the flow and pressure changes are in phase; that is, they occur simultaneously. Attenuation of pulsations in a cross-country oil line is normally great enough to prevent reflections from the distant end.

The following are used in analyzing the pulsation dampener:

a = velocity of pressure surge, feet per second.
e = voltage in equivalent electrical circuit.
f = frequency of pulsation, cycles per second.
g = gravity constant = 32.2.
h = pipe wall thickness, feet.
i = current in equivalent electrical circuit.
j = complex operator = $\sqrt{-1}$.
k = bulk modulus of liquid, pounds per square foot.
k' = effective bulk modulus, pounds per square foot.
p = pressure, pounds per square foot.
q = flow rate, cubic feet per second.
t = time, seconds.
y = length of choke tube, feet.
ν = Poisson's ratio.
ρ = fluid density, pound-mass per cubic foot.
$\omega = 2\pi f$.
A = cross-sectional area of pipe, square feet.
B = cross-sectional area of choke tube, square feet.
C = capacitance of surge chamber, feet^3 per pound-force.
D = pipe diameter, feet.
E = modulus of elasticity of steel in pipe wall, pounds per square foot.

L = inductance of choke tube, pound-force per second^2 per foot.[5]
R = pipe resistance, pound-force per second^2 per foot.[6]
R_o = surge resistance of pipe line, pound-force per second^2 per foot.[6]
V = volume of surge chamber, cubic feet.
P = peak pulsating pressure of given frequency, pounds per square foot.
P_o = peak pulsating pressure without surge chamber and choke tube, pounds per square foot.
P_p = peak pulsating pressure at pump with surge chamber and choke tube, pounds per square foot.
P_L = peak pulsating pressure at line with surge chamber and choke tube, pounds per square foot.
Q = peak pulsating flow rate of given frequency, cubic feet per second.

First, develop expressions for the capacitance of a surge chamber and the inductance of a choke tube. For the surge chamber, note that:

$$\frac{dp}{dt} = \frac{k'}{V} q \qquad (1)$$

if fluid is flowing into the chamber at the rate q. The equivalent equation for an electrical condenser is:

$$\frac{de}{dt} = \frac{i}{C} \qquad (2)$$

so, if pressure is analogous to voltage and flow rate is analogous to electrical current, the surge chamber capacitance is:

$$C = \frac{V}{k'} \qquad (3)$$

The equivalent inductance of a choke tube can be determined by application of Newton's second law which states

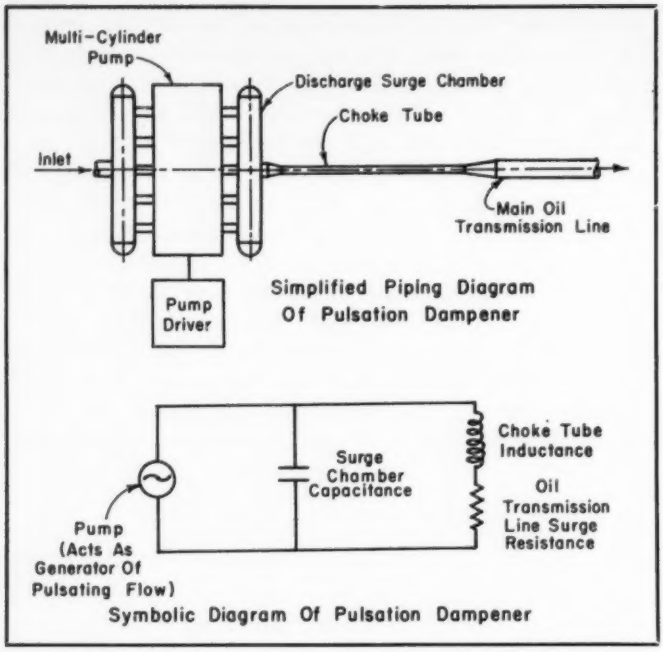


FIGURE 2—A simple pulsation dampener installed on a pump discharging directly into a long pipe line. Symbolic sketch of system compares it with an electrical circuit. The pump is considered to be a constant-current generator having both a steady and a pulsating component.

that force is proportional to mass times acceleration. Thus, if frictional effects are neglected,

$$P = \left(\frac{\rho y}{gB}\right)\left(\frac{dq}{dt}\right) \tag{4}$$

This relation assumes that the entire contents of the tube are accelerated simultaneously. A more involved analysis is necessary if the time for the pressure pulse to travel the length of the tube is a substantial fraction of the period of the pulsating pressure. Equation (4) can be used if the length of the tube is small compared to the wave length of the pulsation. (The wave length is the distance between pressure peaks of a wave traveling through the pipe; it is equal to the velocity of the wave divided by the frequency of the pulsation.) Practically, equation (4) may be used without correction if the tube length is less than one-eighth wave length. The equivalent equation for a lumped electrical inductance is:

$$e = L\left(\frac{di}{dt}\right) \tag{5}$$

Thus, the inductance of a choke is:

$$L = \frac{\rho y}{gB} \tag{6}$$

The expression for the surge resistance of a long oil transmission line may be obtained directly from the familiar water-hammer equation:

$$p = \left(\frac{\rho a}{gA}\right) q \text{ or } p = \left(\frac{1}{A}\sqrt{\frac{k'\rho}{g}}\right) q \tag{7}$$

since the wave velocity in a pipe line is:

$$a = \sqrt{\frac{k'g}{\rho}} \tag{8}$$

The surge resistance is then:

$$R_o = \frac{\rho a}{gA} \text{ or } R_o = \frac{1}{A}\sqrt{\frac{k'\rho}{g}} \tag{9}$$

The effective bulk modulus, k', is slightly less than the bulk modulus of the liquid in a long pipe line because of the stretch of the pipe wall. Its value for a pipe line restrained against longitudinal movement is:

$$k' = \frac{k}{1 + \frac{kD}{Eh}(1 - \nu^2)} \tag{10}$$

Its value for a surge chamber, which is not restrained against longitudinal movement is:

$$k' = \frac{k}{1 + \frac{kD}{Eh}(1.25 - \nu)} \tag{11}$$

The pulsating flow from a reciprocating pump is periodic and may therefore be represented by a Fourier series of sine or cosine terms. The response of the filter is the sum of the responses to the separate frequency components. Thus, a filter which is effective for each distinct component will be effective for the actual pulsating flow which is the sum of these components. An effective pulsation dampener for a 5-cylinder pump must provide filtering for a fundamental frequency of 5 cycles per revolution. But higher harmonics will also be present, so it should also be capable of filtering out integer multiples of the fundamental frequency. Complete elimination of pulsation is not necessary for the normal installation.

The expressions for numerical calculation of the capacitance, inductance, and resistance of the pulsation dampener of Figure 2 have now been established, and one can proceed with its analysis in the same way as for an analogous electrical filter designed to reduce alternating current components in a direct current system. The relations between pulsating flow and pressure for the 3 circuit elements are:

$P = RQ$	for a resistance,	(12a)
$P = j\omega LQ$	for an inductance, and	(12b)
$Q = j\omega CP$	for a capacitance.	(12c)

The quantity, $_{\omega}L$, is defined as the inductive reactance and the quantity, $\frac{1}{\omega C}$ is the capacitive reactance. They have the same units as a resistance. The complex operator, j, indicates that the pulsating flow, Q, lags the pulsating pressure, P, by 90 degrees in an inductance; for a capacitance, the pulsating pressure lags the pulsating flow by 90 degrees. The total pulsating pressure across an inductance in series with the surge resistance of the line is:

$$P = (R_o + j\omega L)Q \tag{13}$$

The total pulsating flow into the filter is the sum of the flow into the capacitance and the choke tube inductance which is in series with the surge resistance of the main pipe line. Thus:

$$\text{Total } Q = \left(j\omega C + \frac{1}{R_o + j\omega L}\right)P_p \tag{14}$$

Solving for P_p:

$$P_p = \left(\frac{R_o + j\omega L}{1 - \omega^2 LC + j\omega R_o C}\right)Q \tag{15}$$

Now, suppose the pump discharged directly into the line with no inductance and capacitance. Then:

$$P_o = R_o Q \tag{16}$$

Thus, the ratio of pulsating pressure with a filter to that with no filter is:

$$\frac{P_p}{P_o} = \frac{1 + j\left(\frac{\omega L}{R_o}\right)}{1 - \omega^2 LC + j\omega R_o C} \tag{17}$$

Similarly, the ratio of pulsating pressure at the start of the line with and without the filter is found to be:

$$\frac{P_L}{P_o} = \frac{1}{1 - \omega^2 LC + j\omega R_o C} \tag{18}$$

One is normally interested only in the magnitudes of these vectors, which are:

$$\frac{P_p}{P_o} = \sqrt{1 + \left(\frac{\omega L}{R_o}\right)^2}\left(\frac{P_L}{P_o}\right) \tag{19}$$

$$\frac{P_L}{P_o} = \sqrt{\frac{1}{(\omega^2 LC - 1)^2 + (\omega R_o C)^2}} \tag{20a}$$

or, identically,

$$\frac{P_L}{P_o} = \sqrt{\frac{1}{\left[\left(\frac{\omega L}{R_o}\right)^2 \frac{CR_o}{L} - 1\right]^2 + \left(\frac{\omega L}{R_o}\right)^2 \left(\frac{CR_o}{L}\right)^2}} \tag{20b}$$

The value of pulsating pressure at the start of the line is of greatest interest. The pulsating pressure at the pump discharge is greater, but this occurs in a short, heavy, and rigidly supported surge chamber that is not free to vibrate. The pulsating pressure at the pump suction can, however, be important for pumps with a low mean suction pressure.

The curves of Figure 3 illustrate the effect of frequency on the performance of pulsation dampeners with several different values of the parameter $\frac{CR_o^2}{L}$. This parameter is, for practical purposes, a function only of the system dimensions. It reduces to:

$$\frac{CR_o^2}{L} = \frac{VB}{A^2 y} \tag{21}$$

if k' is the same for the surge chamber as for the pipe line. It appears that $\frac{CR_o^2}{L}$ should be greater than unity if substantial amplification at low frequencies is to be avoided. Forcing frequencies below the normal design range may occasionally occur because of operation at reduced speed or because of unbalanced performance of the various pump cylinders.

Design of a simple pulsation dampener. For example, let's check the design of a pulsation dampener for a 10-cylinder 360-rpm pump discharging 26,000 barrels per day of diesel oil into an 8-inch line. The pump has two horizontally opposed banks of 5 single-acting cylinders, so the theoretical pulsating flow characteristic is the same as for a double-acting 5-cylinder pump which, in turn, is substantially the same as for a single-acting pump. The fundamental frequency of pulsating flow would be 10 cps for an ideal pump with no valve leakage, etc.

Actually, each side of the pump will generate 30 cps pulses but, with a symmetrical piping arrangement, the fundamental 30 cps component of these pulses will tend

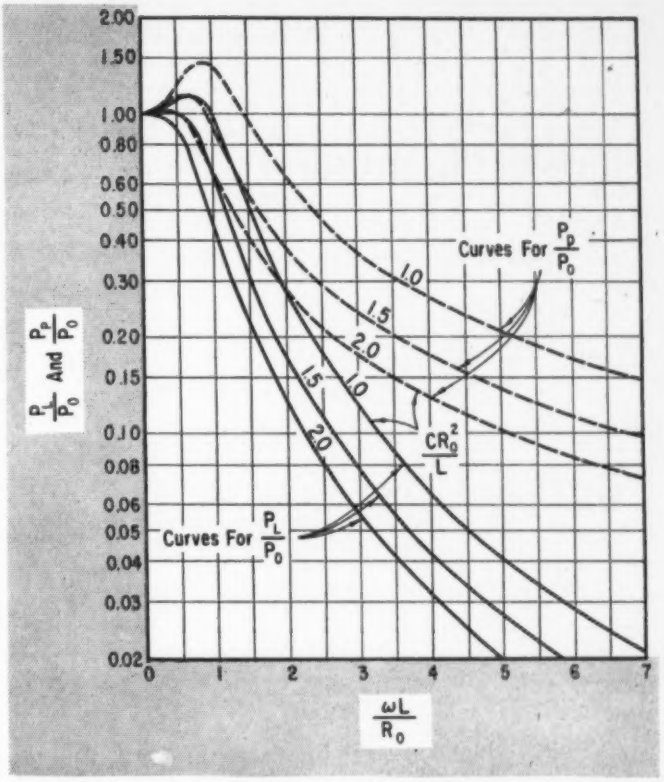


FIGURE 3—Pressure reduction ratios for a single surge chamber and choke tube connected to a long oil or products pipe line.

to cancel out at the point where the flow joins from each bank of 5 cylinders. Preliminary design calculations and physical limitations have led to a surge chamber volume of 16 cubic feet. This volume includes the header volume for each bank of 5 cylinders plus the volume of a large cross connection. A 4-inch diameter choke tube is connected at the midpoint of the cross connection.

Other pertinent data are:

$A = 0.347$ sq. ft. (flow area of 8-inch pipe).
$B = 0.0885$ sq. ft. (flow area of choke tube).
$k' = 150{,}000$ psi $= 21{,}600\,000$ psf.
$V = 16$ cu. ft. (surge chamber volume).
$y = 8$ ft. (choke tube length).
$\rho = 53$ lb. per cu. ft. (oil density).
$q = 26{,}000$ bpd $= 1.68$ cfs.

From these data:

$$C = V/k' = .74 \times 10^{-6} \text{ ft.}^5 \text{ per lb.-force.}$$

$$L = \frac{\rho y}{gB} = 149 \text{ lb.-force sec.}^2 \text{ per ft.}^5$$

$$a = \sqrt{\frac{k'g}{\rho}} = 3620 \text{ fps.}$$

$$R_o = \frac{\rho a}{gA} = 17{,}200 \text{ lb.-force sec. per ft.}^5$$

$$\frac{CR_o^2}{L} = \frac{VB}{A^2 y} = 1.47.$$

Values of other quantities at 30 and 60 cps are:

f		30 cps	60 cps
ωL		28,100	56,200
$\frac{\omega L}{R_o}$		1.63	3.27
$\omega^2 LC$		3.92	15.7
$\frac{P_L}{P_o}$	[from equation (20b) or Figure 3]	0.378	0.0645
$\frac{P_p}{P_o}$	[from equation (19) or Figure 3]	0.723	0.220

The mean flowing velocity in the 4-inch choke tube is

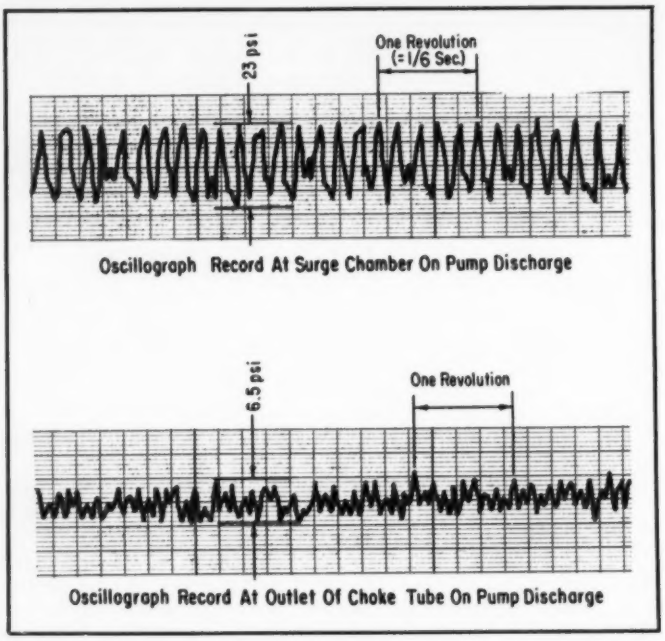

23 psi
One Revolution
(=1/6 Sec)
Oscillograph Record At Surge Chamber On Pump Discharge
6.5 psi
One Revolution
Oscillograph Record At Outlet Of Choke Tube On Pump Discharge

FIGURE 4—Records of pulsation dampening effect for a 10-cylinder pump operating at 360 rpm. Note difference in scale between surge chamber and reading at outlet of choke tube.

19 fps and the calculated pressure loss, with due allowance for fittings, is 5 psi, well within acceptable limits.

Calculations indicate that this pulsation dampener should remove about 94 percent of the 60 cps pulsations but only 62 percent of the 30 cps pulsations. Actual performance records are shown in Figure 4. The total pulsating pressure range was 23 psi at the pump discharge and 6.5 psi at the outlet of the choke tube.

Unfortunately, no performance data are available for this pump, or a similar unit, with no pulsation dampener. Note the prominent 30 cps pulsation at the pump discharge. Theoretically, as already mentioned, the 30 cps components from each side of the pump should cancel out.

In this case, however, the pulsation record was taken at one of the two pump discharge headers and the distance between headers was sufficiently great that the cancellation did not occur at this point. A 60 cps pulsation is most prominent at the choke tube outlet, as would be expected.

Choke tube resistance may be small. So far, only the effect of fluid inertia, or inductive reactance, in the choke tube has been considered, but a resistive term must also be included for a complete analysis of the pulsation dampener. This resistance is generally small and, for a simple filter of the type which has just been analyzed, may either be neglected or added directly to the surge resistance of the line to which the choke tube is connected. At this point the analogy between fluid flow and flow of electrical current breaks down to some extent. The pressure drop for turbulent fluid flow is substantially proportional to the square of the flow rate, whereas the voltage across an electrical resistance is directly proportional to the current. In the choke tube, however, the flow variation is only a small fraction of the total flow so one may use a "dynamic" resistance defined as:

$$R = \frac{dp}{dq} \qquad (22a)$$

Then, if p is proportional to the square of q:

$$R = 2\left(\frac{p}{q}\right) \qquad (22b)$$

in which p is the total pressure drop across the choke tube for the mean flow, q. For the 4-inch choke tube of the illustrative example,

$$R = 2\left(\frac{5 \times 144}{1.68}\right) = 860 \text{ lb.-force sec. per ft.}^5$$

This is small compared to a figure of 17,200 for the surge resistance of the 8-inch line, and may ordinarily be neglected. Resistance values so calculated have been used in the attenuation equation for long transmission lines with results that check quite well with actual measured attenuation of pulsations along an oil pipe line.

Parallel operation of pumps should be considered. An interesting case for which the choke tube resistance may become important is that of parallel operation of two pumps each of which is equipped with pulsation dampeners of the type already described. Assume that the two pumps are alike and are operated at substantially the same speed. Then the net line pulsations at any particular frequency may add or cancel, depending on the phase relation between the two pumps.

Thus, the effective surge resistance of the line, as viewed from either pump, can vary all the way from twice the actual surge resistance to zero. The case of zero surge resistance is particularly important because the choke tube resistance is then the only resistance left to limit the magnitude of pump pulsating pressure if the pump should generate a pulsating flow of the resonant frequency of the surge chamber-choke tube combination. This condition occurs when:

$$\omega^2 LC = 1 \qquad (23)$$

and, from equation (15), the magnitude of the pump pulsating pressure for the resonant condition becomes:

$$P_p = \omega L\left(\frac{\omega L}{R}\right)\left(\sqrt{1+\left(\frac{R}{\omega L}\right)^2}\right)Q \qquad (24)$$

The pulsation dampener of the illustrative example is resonant at a frequency of 15.1 cps at which frequency $L = 14{,}200$ and $\frac{\omega L}{R} = 16.5$ so that $P_p = 234{,}000Q$. For a peak pulsating flow at this frequency equal to 2 percent of the average flow of 1.68 cfs, $P_p = 7{,}860$ psf = 55 psi. Actually, this pump could not generate a pulsating flow frequency of 15.1 cps unless it were operated at approximately half normal speed.

Let's check one actual case of resonant pulsations with two 4-cylinder pumps operating in parallel. The pumps generated a relatively weak first order pulsation in addition to the major fourth order pulsation and, as it turned out, the surge-chamber-choke-tube combination was close to resonance for this first order pulsation. The pumps were driven by induction motors which operated with a very slight speed difference so that the line pulsations alternately added and cancelled over a period of about 6 minutes, as indicated by a measured periodic variation of the pump pulsating pressure from 18 psi to 160 psi.

This large variation in first order pulsating pressure at

the pump caused no apparent change in mechanical vibration, probably because the pulsation was contained in a relatively short surge chamber throughout which the instantaneous pressure was uniform. Pulsation dampeners did an effective job of reducing pulsations in the connected piping.

Dampener design may be varied to take advantage of Resonance. Many variations of the simple pulsation dampener are possible. For example, a surge chamber can be connected to the pump suction or discharge header through a short branch line. Proper sizing of the branch connection will make this system resonant at any desired frequency and greatly increase the effectiveness of the surge chamber for that frequency. This system can be particularly effective if a resonant branch chamber is used in conjunction with a through-flow chamber. The resonant chamber can then be tuned to the lowest pulsation frequency component so that the through-flow chamber need be designed to remove only the higher harmonics.

The tuning cannot be exact because of possible variation in liquid compressibility and pump speed, but actual analysis does show that a tuned vibration absorber can be economically advantageous even for variable speed operation, especially for pumps operating at relatively low speeds. Such a design has actually been used on a 5-cylinder pump designed to operate from 100 to 150 rpm.

A variant of the tuned surge chamber is a closed branch pipe designed to have a length of one-quarter wave length at the frequency to be absorbed. Such a branch line will develop a very high pulsating pressure at the closed end and a low pulsating pressure at the open end where it is connected to the pump suction or discharge. It will also absorb odd harmonics of the design frequency.

A possible disadvantage of the tuned branch line is that mechanical vibration can result from the instantaneous difference of pressure at the two ends. Incidently, it is not necessary that the quarter wave length branch be physically straight, although a straight branch can be expected to have less mechanical vibration.

Pressure pulsation forces could, of course, be balanced by use of two straight quarter wave length tubes extending in opposite directions. For the same reason, connections to a cylindrical surge chamber should preferably be made at the midpoint of the chamber.

High frequency pulsations most troublesome. Low-frequency pulsations are, for most systems, considerably less troublesome than high-frequency pulsations. Damaging pipe vibration arises from the fact that, at a given instant, the fluid pressure is not uniform at all points in the piping system. The difference between points of maximum and minimum pressure is one-half wave length, or 360 feet for a 5-cps wave with a velocity of 3600 fps. The distance is only 30 feet for a 60-cps wave. The probability of substantial instantaneous pressure differences within unanchored lengths of station piping is thus much greater for high-frequency pulsations than for low-frequency pulsations.

Another approach is to view the unsteady flow as a series of short pulses which cause serious pipe vibration as they travel past changes of direction. The pulsation dampener described does an effective job of removing the high-frequency components, which are responsible for the sharpness of the pulse, leaving only a residue consisting primarily of a simple sine wave with the frequency of the pulse. Even this fundamental frequency is appreciably reduced by the pulsation dampener.

Resonant amplification of pulsations should be considered. The most important contributor to excessive pressure pulsations is the resonant amplification of pressure pulsations in the system itself. Most piping systems are relatively complex so it becomes almost impossible to anticipate and avoid resonant amplification of one of the many frequencies generated by the irregular flow from the pump.

Again, resonance is most likely to occur with high-speed pumps since the shorter lengths necessary for resonance are most common in the usual piping system.

Finally, it can be shown that the effective dampening of pulsations at high frequencies is less than at low frequencies. For example, compare two closed one-fourth wave-length branch connections, one of which is resonant at a low frequency and one at a high frequency. By reference to electric-circuit theory, the following close approximation may be written:

$$\left(\frac{P_2}{P_1}\right)=\left(\frac{4}{\pi}\right)\left(\frac{\omega L}{R}\right)=\frac{2}{R}\sqrt{\frac{L}{C}}=\frac{2}{BR}\sqrt{\frac{\rho k'}{g}} \quad (26)$$

Where:

$\frac{P_2}{P_1}$ = $\frac{\text{pulsating pressure at closed end of tube}}{\text{pulsating pressure at open end of tube}}$

L = total inductance of tube.
R = total flow resistance of tube.
C = total capacitance of tube.
B = cross-sectional area of tube.

Equation (26) indicates that, for a given cross-sectional area, the pulsating pressure amplification is inversely proportional to the flow resistance of the tube. For high frequencies, the resonant length is short and the corresponding resistance is low. Therefore, the pressure pulsation amplification will, in general, be directly proportional to frequency.

This greater pressure amplification can more than offset the apparent advantage of more nearly uniform flow

About the Author

MILTON LUDWIG, a member of Phi Beta Kappa, has an A.B. degree in electrical engineering from Stanford University. He joined the Engineering department of Standard Oil Company in 1934, taking leave in 1941-42 to teach in the Mechanical Engineering department at the University of California. He also did consulting work in 1951 with California Research and Development Corporation on the atomic energy project. Most of Ludwig's work with Standard of California has been in mechanical engineering, involving heat transfer problems, fluid mechanics, pipe line and pressure vessel design and special stress-analysis problems.

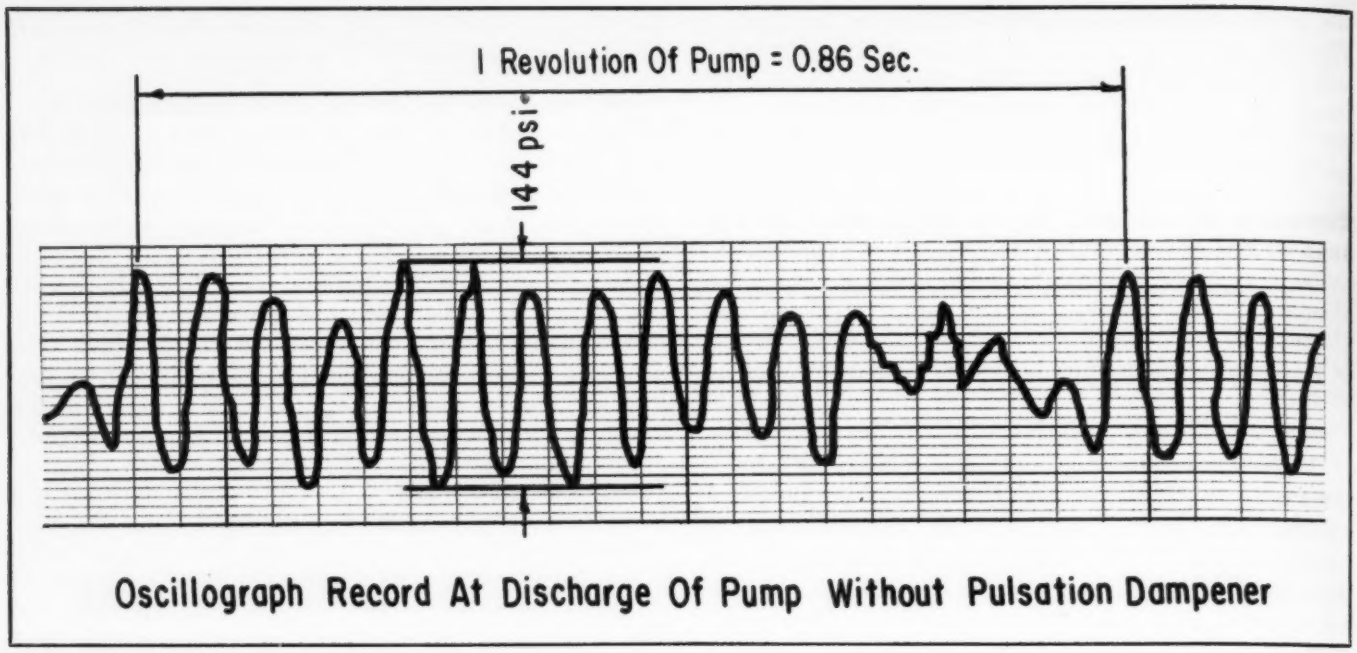


FIGURE 5—Pulsations experienced from a double acting duplex pump operating at 70 rpm without pulsation dampener. Oscillations at about 16 cycles per revolution overshadow dominant flow pulses at 4 cycles per revolution. This is caused by resonance in the lead-out line.

from the multi-cylinder, high-speed pump. Pulsation dampeners are highly desirable for this type of pump.

Pump performance without a pulsation dampener. Consider the case of a pump that discharges directly into a lead-out line with no surge chamber at the pump. Assume that the lead-out line in turn discharges directly into the start of a long transmission line of larger diameter. Then, for a pulsation frequency such as to make the lead-out line equal to one-fourth wave length,

$$P = \left(\frac{A}{B}\right)^2 R_o Q \qquad (27)$$

in which A is the cross-sectional area of the main pipe line and B is the cross-sectional area of the lead-out line. R_o is the surge-resistance of the main line. Thus, the pulsating pressure of the pump is amplified by the factor $\left(\frac{A}{B}\right)^2$.

In the actual system, however, the main line will have additional branches which will act as capacitive loads on the lead-out line. The effect of such capacitances is to increase even further the possible pulsating pressure at the pump discharge.

With two pumps on the line, as already mentioned, it is possible for pulsations of a given frequency to cancel out and to produce the equivalent of an infinite capacitance at the start of the main line. The damping effect of the surge resistance of the main line is then entirely lost so that pulsating pressures at the pump discharge can be very large if one of the pulsating flow frequency components should equal the resonant frequency of the lead-out line.

A striking example of resonant pressure pulsations at the discharge of a low-speed double-acting duplex pump is shown by the oscillograph records of Figure 5. The dominant pulsating flow frequency from such a pump is four cycles per revolution and a substantial pressure pulsation might reasonably be found at this frequency.

This frequency is, however, almost completely obscured by a strong pulsation at 16 cycles per revolution, or 18.5 cps for the pump speed of 69 rpm. This 18.5 cps pulsation was very puzzling at the time the tests were run, but further study revealed that the 40-foot length of 6-inch lead-out line was approximately equal to one-fourth wave length for a frequency of 18.5 cps. Thus, the relatively weak 16th order pulsating flow component from the pump generated a very large pressure pulsation. The magnitude of this pressure pulsation was greater than could be accounted for by equation (27), probably because of capacitance of the main 10-inch header and its branches to two other pumps, which were not operating at the time of the test.

The important practical lesson taught by this test is the extent to which very small flow pulses can be amplified into large-pressure pulsations with a resonant piping system. The theoretically calculated 16th order pulsation from a double-acting duplex pump is only 2/255 of the average flow. This compares with a factor of 2/99 for the major 10th order pulsation from a single-acting quintuplex pump. Thus, the pulsating pressure for a quintuplex pump of the same average capacity would have been 255/99, or 2.58, times as great if such a pump had operated at 185 rpm (ten times the resonant frequency of the system.)

The practical importance of considering the effect of flow pulsations from high-speed multi-cylinder pumps thus is demonstrated by this test on a low-speed pump.

Finally, compare the pressure pulsation range of 144 psi for the 12,500-bpd duplex pump operating at 69 rpm with the pulsating pressure range of 23 psi at the discharge of the 26,000-bpd ten-cylinder pump operating at 360 rpm. There is every reason to believe that the pulsating pressure for the ten-cylinder pump would have been greater than for the duplex pump if it had discharged into a similar system without a pulsation dampener.

ACKNOWLEDGMENT

Presented at the Seventh Annual API Spring Pipe Line Conference, Houston, May 14, 1956, under the title of "Design of Pulsation Dampeners for High-Speed Reciprocating Pumps."

Lee College campus in Baytown, Texas, site of School of Pipe Line Technology.

AN API FEATURE

API Starts Pipe Line School

Course is planned primarily for supervisors and prospective leaders. First six-week session to start at Lee College, Baytown, Texas, in October.

THE NEW API Transportation Division School of Pipe Line Technology will supplement the technical education and field experience of crude and products pipe line men. It is a step taken by the API group to provide better qualified industry leaders for the future.

The course covers design, construction, operation and maintenance of main lines, gathering systems, tank farms, terminals and stations. Personnel problems, scheduling, dispatching and communications are also to be studied.

The school, operated by the University of Texas Petroleum Extension Service, will be located at Lee College in Baytown, Texas. The first six-week course starts October 8 with enrollment limited to 30 scholarships. Applications are still being accepted.

Two or more men may rotate attendance on a single scholarship. The scholarship, which covers all school expenses and transportation on field trips, costs $300. This does not cover living expenses.

15 Topics of Study to Be Offered

Economics and History of Pipe Line Transportation
History of industry with economic analysis. Present roll of pipe line transportation in nation's economy, with a look to future developments.

Personnel Organization
Case studies of typical pipe line organizations with reference to executive and departmental functions.

Industrial and Public Relations
Vital functions of line supervision in business operations. Relations within the pipe line industry, oil industry and community as a whole.

Main Line Design and Construction
Economic and technical considerations in the planning, design, specification and construction of crude and products lines.

Main Line Maintenance
Development of preventive and remedial maintenance of trunk line facilities. Study of new techniques.

Main Line Corrosion Control
Operating techniques and remedial and preventive maintenance program to mitigate internal and external corrosion of main lines.

Gathering Systems Design and Construction
Procurement and analysis of production data. Estimating economic life of system. Survey, specification and building complete gathering facilities.

Gathering Systems Operation and Maintenance
Transfer of custody of crude oil and products. Carrier and shipper relationship. Efficient and economical operation techniques.

Main Line Tank Farms
Economic and technical factors in location and design. Construction and equipment. Maintenance.

Terminals
Terminals in general. Loading facilities, land and offshore, for barges and sea-going vessels.

Main Line Stations Design and Construction
Design of buildings and unattended stations. Selection and arrangement of equipment.

Main Line Stations Operation and Maintenance
Oil movement coordination with shippers, consignees and maintenance work. Purchasing, warehouse, accounting, salvage and reconditioning functions.

Scheduling and Dispatching
Analysis of data for centralized and decentralized control. Unattended stations. Batching cycles. Segregation of tenders.

Communications
Company-owned systems. Leased facilities. Public facilities.

Reclaiming and Salvage
Economic and legal factors in salvaging abandoned facilities.

Truck-mounted equipment is most efficient means of spraying herbicides along pipe line right-of-way. Operators must use care to make sure that spray does not carry with the wind and damage cultivated crops.

Chemicals Speed Brush Control

New type herbicides cut weed and brush control costs up to 80%. Proper use of the right chemical will keep right-of-way clear.

By J. F. ALLEN
Davey Tree Expert Company
Webster Groves, Missouri

CHEMICAL HERBICIDES are helping pipeliners fight the long-standing problem of brush control. Pipeliners are continuously fighting foliage growth in repair work and constructing new facilities. Weeds are a hazard to line coatings. Roots seek out holidays, damaging the coating and increasing corrosion protection problems.

A method of eliminating or at least restricting brush growth can save operators many dollars. To be economical, the initial cost must be low and the job must last for several seasons. Proper precautions must be taken to protect crops and livestock of the landowners.

A complete economic evaluation of this new chemical method of brush control has not been made, but companies which have used chemical controls for five years have reported right-of-way maintenance savings of 50 to 80 percent.

Chemical control is efficient because the results are cumulative. Brush cutting progressively *increases* the density because each stem cut off sends up several new sprouts. Herbicides

New type weed killers provide safety and better housekeeping at pipe line terminals and tank farms. Application may last from a few months to several seasons.

On the Right-of-Way

progressively *reduce* the brush stand because the stems die and only seedlings and scattered sprouts of regrowth remain. Each successive treatment costs less than the one before . . . this never was true of the cutting job.

Farmers favor chemical brush control because brush removal increases grass growth. Pasture to a farmer or rancher means beef production and, when he finds his cattle grazing over the cleared pipe line route, he just can't help feeling kindly toward the company that put it there. It is important, however, that the landowner be fully informed about the program and his permission secured before any chemicals are used on his property. The materials in common use today are not poisonous to animals or to humans. Most farmers know this, but they should be given detailed identification of the chemicals used and assured of their safety, if such assurance is needed.

Watch for Wild Cherry. At the same time it is a good idea to ask the landowner whether there is wild cherry or chokeberry growing on the area to be sprayed. If he is experienced in livestock husbandry, he will recognize the importance of this question, for he knows that the foliage of these plants, when wilted, can be both poisonous and palatable. Cattle, sheep and horses avoid this foliage when it is alive and green because of its bitter taste. When it is wilted, after cutting or spraying, it undergoes a chemical change and is then sweet-tasting and very poisonous. Any bushes of these species should be cut and burned, unless it can be made certain that livestock is not permitted to graze in the area for several days after treatment.

The most widely used and most economical chemical brush control method is the foliage spray, applied during the summer months when the brush is in full leaf and growing actively. The season in the southern states may start about May 1 and run through to mid-September. Farther north the starting time will be May 15 to June 1. Work should be discontinued before the leaves begin to dry out, as growth stops in late summer. A very dry hot season sometimes makes spraying much less effective after August 1.

Select the Right Chemical. The materials most commonly used for summer application are (1) 2,4-D (2,4 dichlorophenoxyacetic acid) esters, (2) 2,4,5-T (trichlorophenoxyacetic acid) esters, (3) combinations of 2,4-D and 2,4,5-T, and (4) ammonium sulfamate. The low volatile esters of 2,4-D and 2,4,5-T (isoctyl, butoxyethanol, butoxy-ethoxy-propanol, and propylene glycol-butyl-ether-esters) have generally produced superior results with less danger to adjacent crops than have the volatile esters, such as, amyl-, isopropyl- or butyl-esters. Ammonium sulfamate is, of course, completely non-volatile. If physical spray drift is accurately and carefully controlled, this material can be used safely in sensitive crop areas.

2,4-D, used alone, has a rather limited application in brush control and

Pack sprayers may be more economical for spraying stumps or brush stubble to prevent resprouting. They are particularly useful in rugged terrain.

is recommended where only such species of brush as buck brush (coral berry), Shinnery Oak or willow are to be treated. It is mixed with water in the ratio of 2 to 4 quarts per 100 gallons and applied with suitable power sprayer in sufficient volume to thoroughly wet the entire leaf and stem surfaces of the plants.

A 50/50 mixture of 2,4-D and 2,4,5-T has been widely used with good results on stands of mixed brush species. The usual spray solution is four quarts of the 50/50 mixture in 100 gallons of water. The application must be in sufficient volume to thoroughly wet all plant surfaces. Other combinations of 2,4-D and 2,4,5-T esters are available, some containing a larger percentage of 2,4-D, some containing more of the 2,4,5-T. Each has its field of application as determined by the relative proportion of the different brush species contained in the mixed brush stand.

2,4,5-T ester mixed in water at 3 quarts for 100 gallons is recommended for solid stands of Osage Orange on which it should produce almost 100 percent control. The same solution has been used extensively on solid stands of oak and hickory with satisfactory results but with somewhat less than complete control.

Ammonium sulfamate is perhaps the least selective of the modern herbicides and has produced a higher percentage of kill on more individual species of brush than any other material in common use. It is mixed in water, to which a few ounces of spreader or wetting agent has been added, at the ratio of 60 to 75 pounds in 100 gallons. Because of the excellent translocation of ammonium sulfamate through the plant, good root kill is achieved. And the intervals between retreatments may be a year or two longer than when the hormone-type herbicides are used.

The cost of material needed to make 100 gallons of this spray solution is somewhat higher than the cost of 2,4D and 2,4,5T. It is also quite corrosive on the truck and spray equipment. Generous use of used crankcase oil on the exposed metal parts of the spray equipment will reduce the corrosive effects of ammonium sulfamate. Experiments are currently being carried out with oil-water emulsions of ammonium sulfamate but there is, as yet, insufficient data from this work to warrant specific recommendations.

Another herbicide which may be described as a "chemical cousin" of 2,4,5-T has been used in recent years on oak and maple brush with very good results. It is a formulation containing low volatile esters of silver acid (2,4,5-T trichlorophenoxy propionic acid). Although it is somewhat slower in action than 2,4,5-T, it has demonstrated a superior ability to control resprouting from lateral roots of treated brush. Recommended use for foliage application is 3 to 4 quarts in 100 gallons of water.

Proper Application Is Important. It should be emphatically said that no chemical herbicide is any better than the technique with which it is applied. Complete coverage of the plant surfaces, including leaves, branches and main stems, is essential. The careful spray operator will take time out occasionally to walk back through the sprayed brush to check on the completeness of the coverage. If dry stems or leaves are noted, the coverage is not satisfactory. If the brush is very dense, it may be helpful to increase the pump pressure in order to better atomize the liquid and reduce the droplet size. Because this will increase the risk of spray drift onto adjacent foliage or crops, extra caution will be necessary where crop damage is possible.

Use Hand Spray in Rugged Terrain. Scattered large brush and brush growing in areas so rough and rocky that even four-wheel-drive equipment can't be used may be effectively controlled by basal spray application. Either knapsack-type sprayers or small

New chemical formulations for brush control are becoming available. Test plots may be used to select the proper one for the specific pipe line problem.

easily portable power sprayers may be used. The method is just what the name implies. The base of the brush stem, from the ground line to a height of 14-18 inches, is thoroughly wet with the spray solution. Sufficient material must be applied to cause noticeable run-off and to thoroughly soak the tough root crown area and exposed roots. The entire circumference of stem and root crown must be covered or considerable resprouting will occur.

The solution recommended for basal spraying is 2,4,5-T in fuel oil or kerosine, mixed at the ratio of 4 to 6 gallons in 100 gallons of oil. Basal treatment is especially advantageous in areas where cotton or tobacco is grown because it can be applied at any season of the year, including the dormant winter and fall months when no crops are present. The cost per acre for effective basal spray is somewhat greater than for the summer foliage spraying because of the added cost of the oil diluent and increased hand labor, but it still compares favorably with brush cutting.

It has also been noted that some resistant or "hard-to-kill" brush species, such as maple, ash, mulberry and hackberry, respond better to basal treatment than they do to summer foliage spraying. Consequently it has special value as a follow-up treatment after one or two foliage sprays have reduced the brush stand to scattered specimens.

How to Treat Stumps. Closely related to basal treatment is the method of stump treatment. If brush is tall and likely to be objectionable if killed and left standing, it may be cut and the stumps and stubble thoroughly soaked with the same solution of 2,4,5-T in oil. This treatment will give 50-85 percent control of resprouting, depending on the thoroughness of application. Fewer stumps and stubble will be missed if they are cut 6-8 inches high. There is also some evidence that the increased stump height increases the amount of spray solution applied and, consequently, improves the percentage of kill. Stump treatment may be the only method which can be used along state and federal highways where regulations forbid spraying of standing brush.

Check State Laws. Mention should be made here of state laws governing the use of herbicides. Most states in which either cotton or tobacco is an important crop have enacted very strict regulating laws. These laws are intended primarily to protect the landowner, but they are also a protection for the pipe line company which may want to use chemical methods for right-of-way maintenance. A letter to the state attorney general's office or a phone call to the county agricultural agent may prevent unnecessary embarrassment or possible penalty for law violation. Licensed custom spray contractors are familiar with the legal requirements governing their work.

Chemical brush control is not a one-shot cure-all for right-of-way maintenance problems. A good long-range program, which may include one or more of the methods mentioned, should be planned in advance and adhered to through the useful life of the right-of-way. Only in this way can the full cumulative benefits and dividends in the form of cost savings be realized. Follow-up treatments at intervals of two or three seasons will protect the investment in the initial treatment and progressively reduce annual costs per mile.

—The End.

This is one of the suspension bridges spanning the Dagua river. Up this river, along the railroad right-of-way for about five miles, the pipe line crosses the narrowing canyon 21 times.

7-Mile Colombian Pipe Line Stretch One of the Toughest

In its 64 miles, the $5.2 million Buenaventura-to-Cali project included:

- **21 canyon crossings**
- **8 underwater crossings**
- **13 suspension bridges**

ONE SECTION of the 64-mile Buenaventura-Cali pipe line in western Colombia has been described as one of the roughest and most difficult lines of its size ever built.

And this is why:

The first section of the pipe line, owned by Empresa del Oleoducto Buenaventura-Cali, Ltda., of Cali which began operating March 5, 1956, was a 2200-foot underwater crossing to the mainland. The next 28 miles, to an altitude of 1000 feet in the foothills and along the highway right-of-way through low, thick, swampy forest, offered no special difficulties. And about 80 percent of the line pipe was buried.

Up the Dagua river, along the railroad right-of-way for about five miles, the pipe line crosses the steadily narrowing canyon 21 times. For the eight under-water crossings, the line pipe was buried four to five feet deep for protection against rocks swept along during high water. Thirteen bridges, averaging 275 feet in length with a maximum of 525 feet, were of the suspension type with concrete anchorage and galvanized bridge cables.

From a point upriver, called Cisneros, the pipe line follows for seven miles an old, three to six-foot wide mule trail hacked out of almost perpendicular mountainside. From the trail to the valley floor, it is a sheer drop varying between 100 and 500 feet. It was this section that earned for the pipe line the distinction of being one of the roughest and most difficult lines of its size ever built.

The pipe was cut into 20-foot lengths, for the entire seven-mile stretch, and hauled by pack trains. For lashing to the wooden pack saddles fore and aft, the pipe was placed on forked sticks. When these were knocked out, the sudden pull of the weight almost threw the mules, but they managed to negotiate the sharp turns on the narrow trail without a single accident. Only once did a man slip off the path. But apart from a few bruises, he was unharmed.

Since the trail snaked in short radius curves, a high percentage of the 20-foot lengths of pipe needed reverse bends and combination bends, and 150-degree angles were not uncommon.

Williams Bros. of Tulsa, Okla., contractors for the project, designed a special hydraulic pipe bender on four wheels which was pulled along the

Williams Bros. of Tulsa, Okla., designed this special hydraulic pipe bender on four wheels for the seven-mile stretch along the mule trail. Pipe was cut into 20-foot lengths and hauled up by pack train. Short radius curves of as much as 150 degrees called for different bends on the same length of pipe, reverse as well as combination bends.

mule trail. The pipe was buried in a three-foot deep trench on the mountain side of the trail, after being wrapped with insulating tape and asbestos felt,

The Puerto Dagua station is about three miles east of the canyon entrance and on a slope at an elevation of 2800 feet. From there to Yumbo, ten miles from Cali, the pipe rises to an elevation of 5300 feet to cross two mountain ranges before dropping into the Cauca river valley of Cali at 3300 feet. The pipe was laid along the hard clay slopes, despite some 45-degree inclinations.

Where the grade was too steep, the pipe was joined uphill and pushed down; in other sections, up to four tractors hauled the trucks uphill. In this entire section, the pipe was tied above ground to concrete skids and anchors, and Williams Bros. constructed about ten miles of hard dirt road from the village of Dagua to the north.

The contractors worked out of four successively established camps: the main camp at Buenaventura, a work train in the Dagua river canyon, Puerta Dagua and, finally, Cali. The work force under Supt. Harold Brady numbered up to 200 men.

Apart from pipe line equipment, the 40-pieces of rolling stock included 12 tractors, four cranes, special handling machines and elevating machines.

Fingertip control is afforded by microwave voice radio employing three relay stations. The pipe line currently is pumping with a pressure of 1100-1200 psi about 9000 barrels daily of crude products. With pressure of 1500 pounds, it can handle up to 20,000 barrels daily. It is equipped to pump butane after a market has been established in the Cali area. Total cost of the project, including rights-of-way, was $5.2 million.

The route was laid out by Pipeline Engineering Company of Dallas, Texas, which also wrote the specifications and acted as owners' engineers for Empresa del Oleoducto Buenaventura-Cali, a $2.8 million corporation formed by Colombian capital, International Petroleum (Colombia) Ltd., (a Standard Oil Company of New Jersey subsidiary) and South American Gold & Platinum Company of New York.

Construction began in March, 1955,

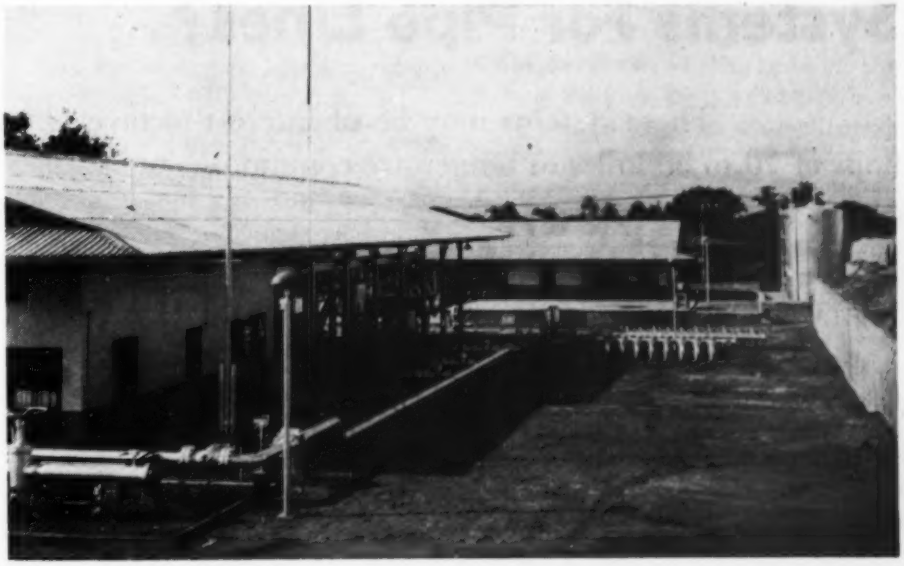
Opening a trail for the pipe line through the woods on the Buenaventura side in the lowlands was no easy task.

and, while the pipe line was finished in January, 1956, delays in auxiliary installations held up the actual pumping until March 5.

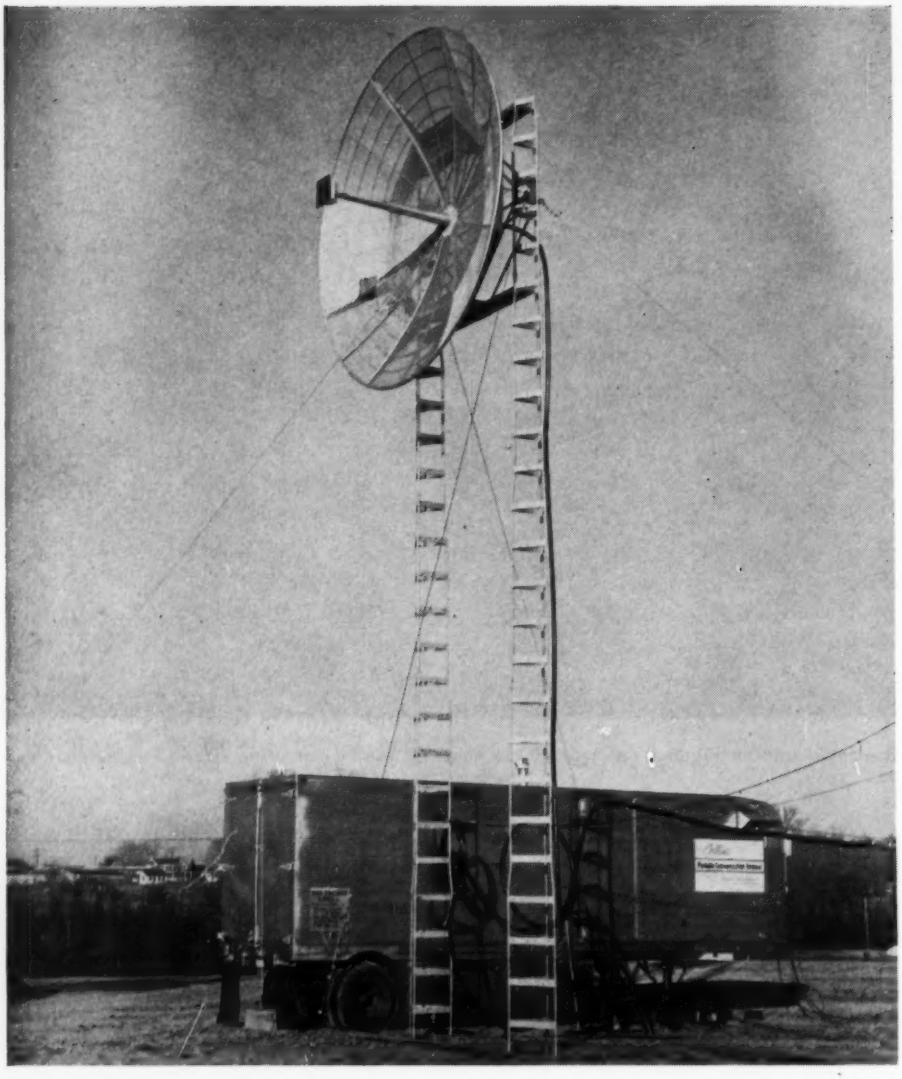
The main station in Buenaventura has vertical type centrifugal booster pumps and two variable stroke reciprocating main line units. The station at Puerto Dagua has two variable stroke triplex pumps and one quinplex pump. Power at the two stations is supplied by industrial type diesel engines. Pipe sizes are 8-inch between Buenaventura and Puerto Dagua, and 6-inch for the 23 miles to Yumbo. All buildings allow for installation of additional units to a capacity of 35,000 barrels a day.

Construction was from Buenaventura eastward toward Cali. The western, coastal Andes, consisting of two main ranges, also are crossed by a narrow gage railroad and a hard dirt highway, but slides during the rainy season frequently interrupt traffic.

The Buenaventura terminal and pumping station required piling because of soft soil conditions not unusual in an area that experiences a 400-inch annual rainfall. **—The End.**



Note the retaining wall on the right at the Buenaventura terminal. The terrain caused considerable headaches because of a 17-foot cut in that corner where the soil was the consistency of water.



Fifteen-foot parabolic antenna set up for tropospheric scatter transmissions. With these systems pipe line communications might be extended to 80 to 100-mile hops.

About the Author

R. M. RINGOEN received B.S. and M.S. degrees in electrical engineering from the State University of Iowa in 1947 and 1948. After graduating he joined the Collins Radio Company in Cedar Rapids, Iowa, and for several years headed work on radio astronomy and development of the radiometric sextant. In 1954 he became head of the Communications Systems group, being primarily concerned with development of VHF and UHF transhorizon systems. At present at Collins Radio he is assistant to the vice president, research and development, with his primary responsibility being coordination and planning of the development of equipment for the fixed communications service.

What About UHF Scatter Systems For Pipe Lines?

These systems may be of interest to several large pipe line companies where hops of 70 to 80 miles or longer are common.

By R. M. RINGOEN
Collins Radio Company
Cedar Rapids, Iowa

THE NEW SYSTEMS offer many potential benefits to cross country pipe lines. They could cut down on the number of repeater stations, reducing costs and maintenance problems. A clearer understanding is needed of the interference characteristics of the systems as compared with present day line-of-sight systems.

Efficient use of the limited spectrum and economical operations are the focal points of interest for pipe line communications, now.

Because most UHF transhorizon (scatter) communications systems employ transmitter powers of 1 kilowatt or greater, it generally is thought that the interference produced by a transhorizon system will be greater than that caused by a line-of-sight relay system performing the same service. The interfering effects of both the transhorizon and line-of-sight relay systems are computed using parameters of existing equipment. A unit of interference defined as a "megacycle-square mile" is introduced and the

interfering properties of each system are expressed, using this term, for one set of assumed conditions.

Results indicate that contrary to general belief, line-of-sight relay systems may actually be considerably more wasteful of spectrum than transhorizon systems. This should be an important factor in determining to what extent UHF transhorizon systems should be employed for pipe line systems in areas where spectrum congestion may exist.

Just what is a "scatter" system? The selection of the word "scatter" has probably been unfortunate in connection with transhorizon VHF and UHF propagation. Most people are familiar with the scattering of light in our atmosphere. Apparently many are of the opinion that scattering of radio waves works the same way and consequently that a tropospheric scatter system will flood a large area with high level signals.

It has been expressed that tropospheric scatter systems will light up the whole sky and interfere with all other facilities on the same frequencies within hundreds of miles in all directions.

Studies indicate that this could hardly be farther from the truth.

To date little information has appeared in literature concerning actual interference which may be expected from tropospheric scatter systems. A comparison of the interference which may be expected from line-of-sight systems and from tropospheric scatter systems is in order. Potential users of tropospheric scatter systems have hesitated because of the general fear that such systems would soon consume all the available spectrum.

By comparing the interference producing capabilities of a line-of-sight system and scatter system performing the same service, some conclusions as to the relative spectrum usage efficiencies of the two types of systems may be drawn.

There are many factors to consider.

1. A scatter system employs much longer circuit lengths while a line-of-sight system essentially acts like a series of r-f amplifiers along the path, producing high intensity fields at specific intervals.

2. Scatter systems use larger and better antennas which have much lower side lobes and narrower main beams. This tends to reduce interference.

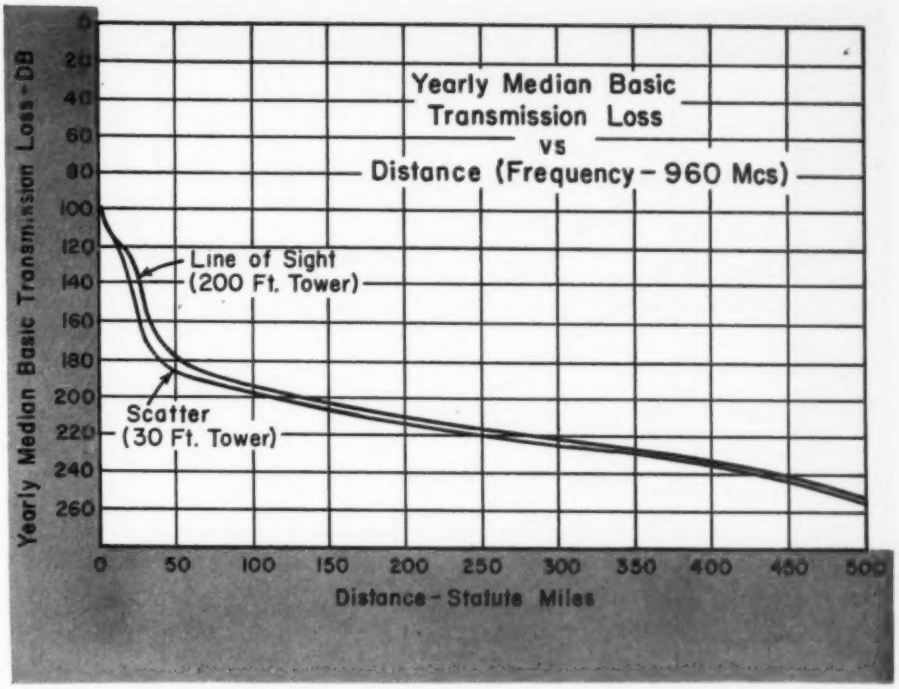


FIGURE 1—Typical curves of yearly medium basic transmission loss for line-of-sight and scatter systems. Over 80 troposheric scatter systems were considered.

3. A scatter system is generally tailor-made to fit the circuit, in that the bandwidth of the intermediate frequency amplifier in the receiver is specifically designed for the channel capacity required. This may not be true in microwave systems and, in practically all cases, more bandwidth than is required is employed in the r-f amplifier.

4. The frequency stability of equipment used for line-of-sight systems is considerably lower than that of equipment used for tropospheric scatter systems. Therefore, appreciable additional i-f bandwidth must be employed in the line-of-sight equipment to accomodate frequency drift.

5. More sensitive receivers are used in the tropospheric scatter systems. This, in conjunction with the much larger receiving antennas, means that tropospheric scatter systems require a much lower field strength on which to operate. Hence, the microwave system must produce a higher field strength at the last terminal in the system than must the tropospheric scatter system.

In addition, most tropospheric scatter systems employ compandors to improve the circuit quality further. These, in turn, reduce the received field strength requirements.

Finally, the line-of-sight systems in general will employ very high towers which will tend to make the propagation loss from the line-of-sight antennas less than that from the lower scatter system antennas.

These factors tend to reduce the interference producing capabilities of UHF scatter systems when compared to a line-of-sight relay system performing the same service.

On the other side of the ledger is, of course, the fact that much higher transmitter powers are employed in UHF scatter systems. However, it should be evident that the other factors mentioned can greatly offset the effect of this one item.

Comparison of the spectrum usage of the two systems. To compare the spectrum usage efficiency of the two systems, compute the interfering properties of a scatter system and a line-of-sight system performing the same specific service.

To utilize specifications from existing equipment, the 960 megacycle region has been chosen. Both line-of-sight and scatter systems are available at this frequency.

The comparison circuit selected is 130 statute miles with a channel capacity of 24 voice channels being required. This channel capacity is representative of an average requirement in the U. S. Using scatter, only one-hop is required, while for microwave

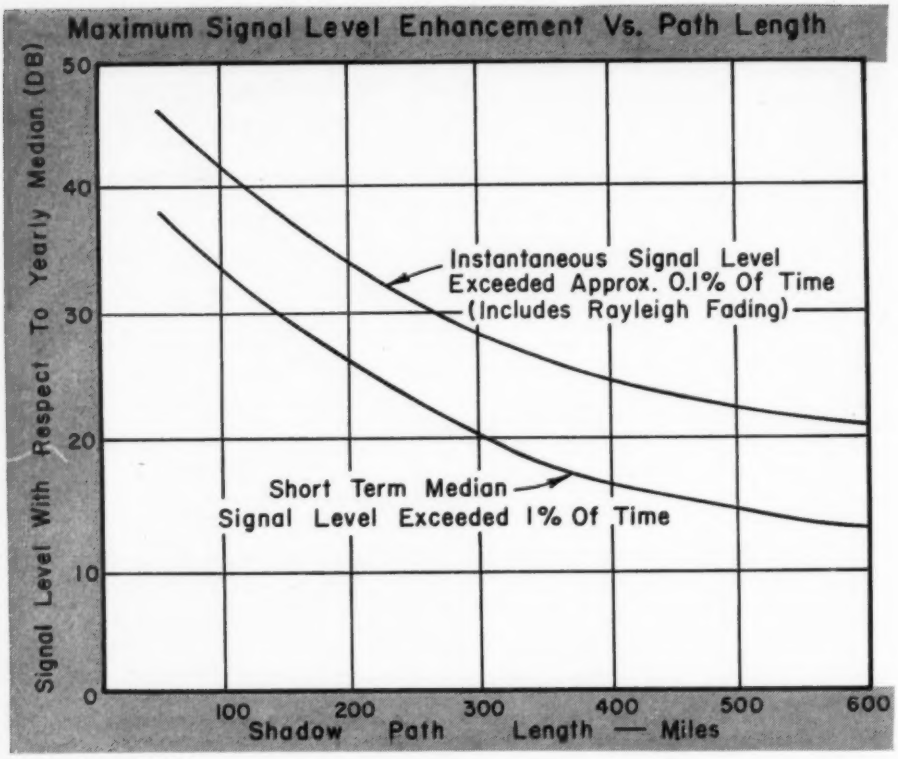


FIGURE 2—Signal level enhancement is caused by atmospheric conditions, super refraction and favorable scattering conditions. Top curve includes effect of Rayleigh fading. Values from this curve will be exceeded less than 0.1 percent throughout the year.

it is assumed that the distance is spanned by four equal 32.5-mile hops.

Specifications for the two systems are listed below:

Line-of-Sight Systems

Length of each of four hops: 32.5 miles.

Median basic transmission loss: 126 db.

Transmitter power: 5 watts.

Loss from transmitter to antenna: 3 db.

Antennas: 8-foot diameter parabolic at each terminal.

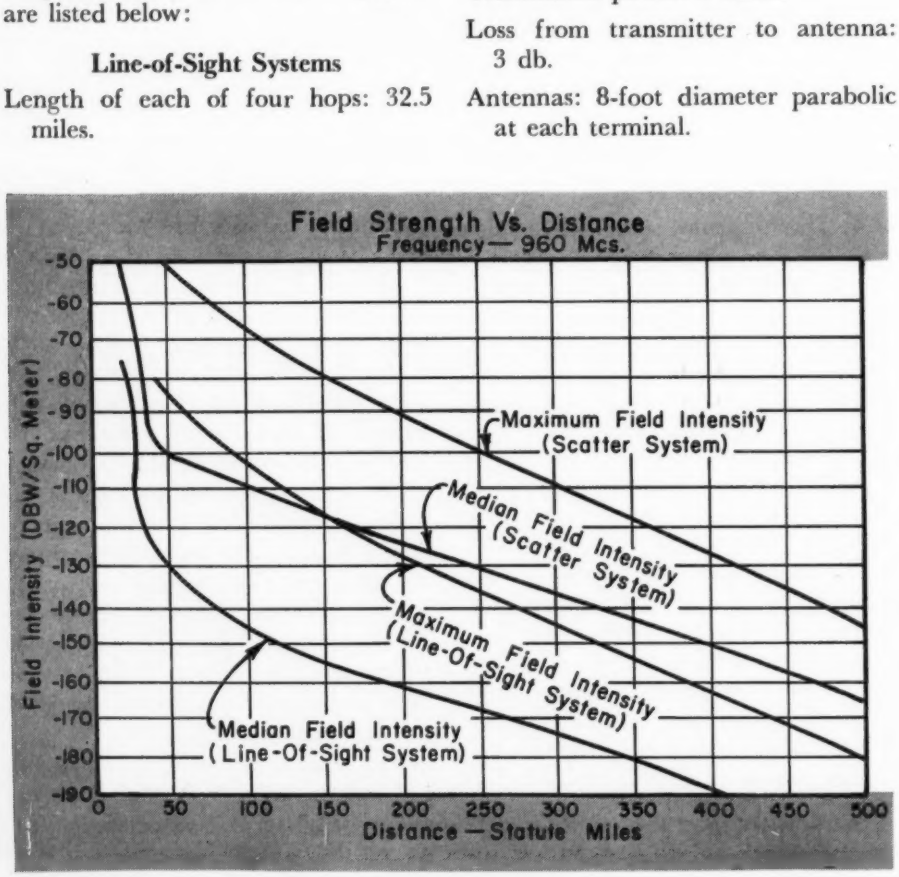


FIGURE 3—The decreasing field intensity with distance gives a comparison of the field strengths of the line-of-sight and scatter systems. Maximum field intensity represents that value which is not exceeded more than 1 percent of the time.

Antenna gain: 25 db with respect to an isotropic.

Receiver bandwidth: 2 mcs.

Attenuation from antenna to receiver: 6 db.

Median received power at receiver input: —78 dbw.

Baseband: 12 to 108 kc (24 voice channels).

Deviation ratio: 3.

FM improvement: 20 db.

Receiver noise figure: 10 db.

Receiver threshold: —121 dbw (—116 dbw at antenna).

For 45 db channel test tone-to-noise ratio, fade margin is 28 db.

Scatter System

Path length: 130 statute miles.

Median basic transmission loss: 202 db.

Transmitter power: 1000 watts.

Loss from transmitter to antenna: Less than 1 db.

Antennas: Two 28-foot diameter parabolic at each terminal arranged for space diversity reception.

Antenna gain: 35 db with respect to an isotropic.

Receiver bandwidth: 1 mc.

Attenuation from antenna to receiver: 1 db.

Median received power at receiver input: —103 dbw.

Baseband: 12 to 108 kc (24 voice channels).

Deviation ratio: 2.

FM improvement: 16 db.

Effective improvement provided by compandors: 19 db.

Receiver noise figure: 7 db.

Receiver threshold: —127 dbw.

For 45 db channel test tone-to-noise ratio, fade margin is 24 db.

Circuit reliability: 99.9 percent.

Field strengths must be determined first. As a basis for computing the field strengths which will be produced by systems operating at 960 megacycles, it is first necessary to derive a curve of basic transmission loss versus distance. Basic transmission loss is defined as the loss between two isotropic radiators.

The curves of yearly median basic transmission loss versus distance used in the computations are shown in Figure 1. Several sources of data have

been used in preparing these curves. Measurements on some 80 tropospheric scatter circuits have been analyzed[1] and a resulting distance dependence curve obtained.

Results of measurements made at Collins Radio over circuits of 100 to 350 miles in length also have been used. In addition, the results of measurements made by MIT at distances out to 600 miles have been incorporated in the curves of Figure 1.

Effect of the higher line-of-sight antenna is readily apparent in Figure 1. The increase in field strength produced by this elevated antenna over that of the lower scatter system antenna is most noticeable at distances below 100 miles.

Yearly median basic transmission loss is of little actual interest when computing the interfering properties of specific systems. More significant is the field strength which is exceeded only a very small fraction of the time. Therefore, the curves of Figure 1 must be modified to take into account anamalous propagation conditions.

The signal level enhancement is plotted as a function of distance in Figure 2. By adding the values in Figure 2 to the transmission loss figures in Figure 1, the transmission loss which is exceeded less than 1 percent of the time may be obtained.

Also plotted in Figure 2 is signal enhancement which may be expected when Rayleigh fading also is taken into account. Due to Rayleigh fading the signal level which is exceeded 1 percent of the time is 8 db above the short term median value. The upper curve in Figure 2 may be assumed to be the signal enhancement which will be exceeded approximately 0.1 percent of the time throughout the year.

This signal level enhancement is caused by ducting conditions, super refraction and by favorable scattering conditions.

Insufficient data are available on the variation in fading range as a function of distance at frequencies in the tropospheric scatter range. However, through analyzing data obtained by the company, MIT and others, the curves in Figure 2 have been derived. These curves may be in error by several decibels because of incomplete data.

Fading range decreases with distance. This is to be expected because during conditions of anomalous propagation, the shadow distance is shortened. A given shortening in terms of miles will have less and less effect on the signal strength at greater distances.

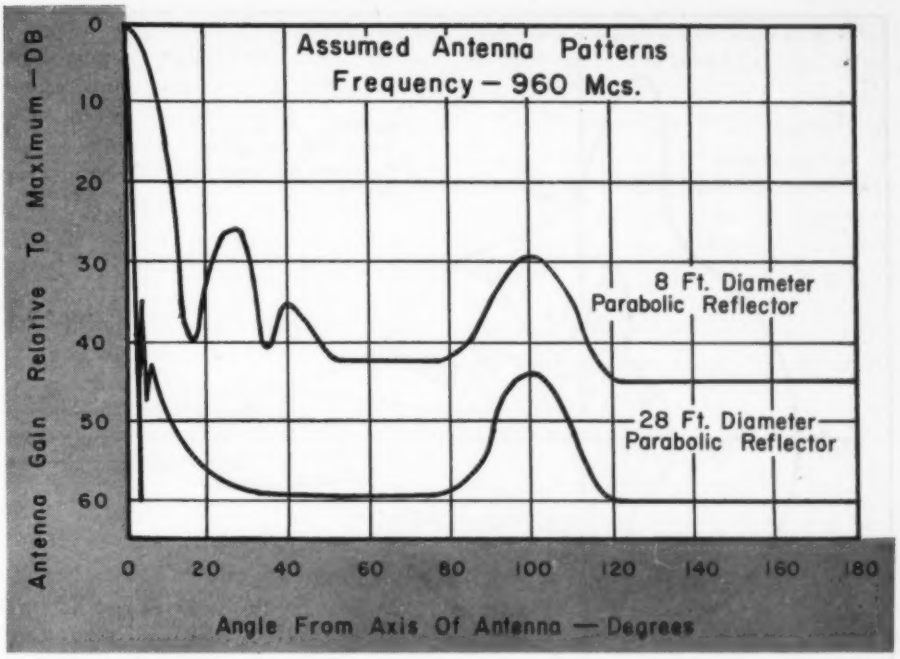


FIGURE 4—A plot of antenna patterns shows areas of possible interference. Manufacturer's data has been used for the 960 mc., 8-foot line-of-sight antenna. Pattern of the 28-foot antenna was computed from measurements on antenna models at higher frequencies.

By using the curves of Figures 1 and 2 and by using the transmitter powers, transmission line losses and antenna gains cited in the specifications, the curves in Figure 3 were drawn.

In Figure 3, the field strength expressed in dbw per square meter is plotted as a function of distance for both the line-of-sight and scatter systems. The curves denoting maximum field intensity for each of the two systems may be assumed to represent the field intensity which is exceeded less than 1/10 of one percent of the time. Therefore, this field strength is the one of interest when considering the interfering properties of the two systems.

These curves, however, are for field strength along the circuit path. To compute the total interference produced, field strength over the entire region must be known. To obtain this information, detailed antenna patterns for both systems must be specified.

Antenna pattern plot useful for interference comparisons. Antenna patterns which have been assumed for the two systems are plotted in Figure 4. Information from manufacturers of 960 megacycle line-of-sight equipment has been used for the eight-foot diameter antenna with a beam width of 8°.

However, for the 28-foot diameter antenna, no accurate experimental patterns were found to be available. Therefore, the pattern plotted for the 28-foot antenna has been derived by computation and by measurements on antenna models at higher frequencies.

As a result, side lobe intensities and back radiation indicated are thought to be reasonable, but are not supported by any detailed measurements on 28-foot diameter antennas.

It is felt that in most actual installations, the radiation in the back direction from large antennas of the type used on tropospheric scatter circuits will result primarily from back scatter from the ground.

Figure 4 shows that the field in the backward direction is 60 db below that along the circuit path. This is believed to be reasonable.

By using the antenna patterns, it is possible to obtain a plot of field strength over the complete area surrounding each of the terminals in the two systems.

Interference field strength basis is selected. To determine the area in which each system will produce signal levels of interfering magnitude, it is necessary to determine the field intensity above which interference will

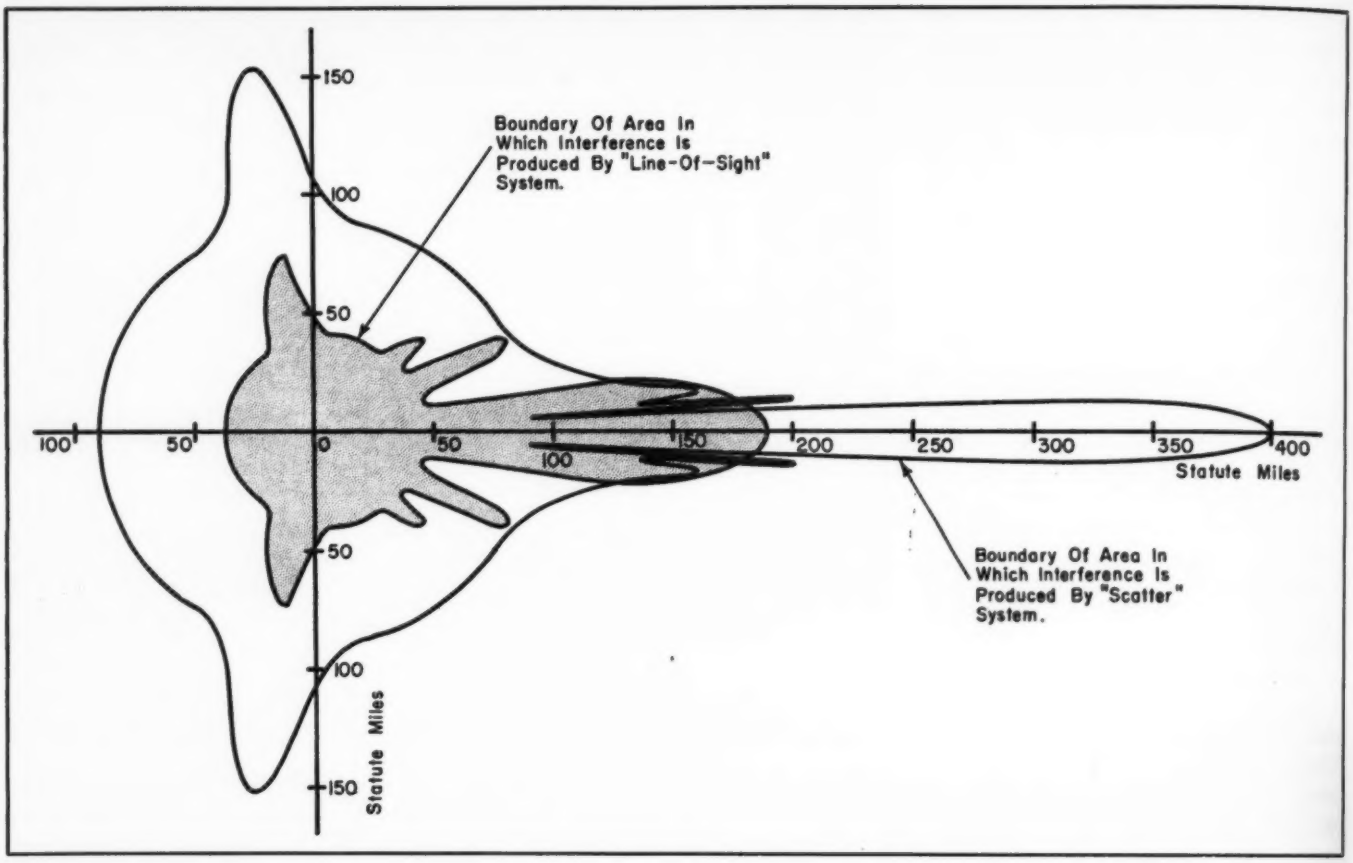


FIGURE 5—A plan sketch shows the area of potential interference produced by the scatter system and the shaded area that of a conventional line-of-sight system. For a 120-mile hop only one scatter leg would be used; the line-of-sight plot would be repeated every 32.5 miles.

result. The determination of this field intensity is somewhat arbitrary and is of not too great importance in the comparison being performed.

The field intensity employed in the computations has been determined by the noise level of the line-of-sight receiver. It is assumed that the field strength reaches an interfering magnitude when it will cause a signal in the receiver for the line-of-sight system which exceeds the receiver noise when the receiving antenna presents an aperture of one square meter to the interfering signal. For the system being analyzed this field intensity value is —125 dbw per square meter.

Over what area will the interference field strength be exceeded? From curves in Figures 3 and 4 along with the limiting field strength value of —125 dbw per square meter, the plot in Figure 5 was made. The area contained inside each one of the curves represents the ground area over which a signal intensity of interfering magnitude will be present.

The scatter system creates interference largely in a narrow strip along the circuit path. Interference produced by the scatter system extends much further along this path than does that of the line-of-sight system.

However, the interference area for only the first line-of-sight terminal has been plotted. Successive interference areas from the remaining three terminals will each be displaced 32.5 miles along the circuit path.

Both ground area and bandwidth considered. A measurement of the interference produced by each system must now be defined. In considering the total properties of each type of system, both the ground area consumed and the bandwidth throughout which interfering signals may be present must be considered.

The term "megacycle-square mile" has been chosen to denote the quantity of interference. This unit represents the product of the bandwidth and area consumed by a given system. For instance, if a system consumed one megacycle bandwidth over one square mile of ground area, the interference produced would be one megacycle-square mile.

For the systems being compared, the line-of-sight equipment has an intermediate frequency bandwidth of 2 megacycles. However, four hops are employed in this system. If the circuits are in line, it is improbably that any frequencies may be reused in the line-of-sight system. Therefore, it may be assumed that each terminal creates interference in a bandwidth of 2 megacycles over the area shown in Figure 5. The total interference in megacycle-square miles is then eight times the enclosed area.

The bandwidth of the tropospheric scatter system is one megacycle and this holds throughout the area enclosed by the single curve for the single transmitting terminal. The total interference produced by the scatter system is therefore simply equal to the enclosed area.

By integrating the areas enclosed by the curves in Figure 5 and multiplying the result by the number of megacycles bandwidth consumed for each case, a measure of the interfering properties of each of the types of systems may be obtained.

In doing this, it is found that the scatter system creates 37,500 megacycle-square miles of interference for each direction of transmission. In con-

trast, the line-of-sight system produces 96,320 megacycle-square miles of interference. These values are for transmission in only one direction for each system.

This comparison indicates that systems employing tropospheric scatter propagation in the 890 to 960 mcs range are not wasteful of bandwidth when compared to present-day line-of-sight systems operating in the same frequency range. In fact, if scatter propagation were employed on all systems in the frequency range, the total circuit miles possible per given allocation bandwidth would be 2.5 times more than if line-of-sight circuits alone were employed.

Equipment refinements for line-of-sight systems would improve comparison. By improving the line-of-sight equipment, its interference producing capabilities may be reduced considerably. For instance, if more sensitive receivers were employed in the line-of-sight systems, less transmitter power would be required. Also, if better antennas were used, the area of interference would be reduced. In addition, if higher frequency stability equipment were employed in the line-of-sight systems along with somewhat lower deviation ratios, the bandwidth could be reduced considerably.

All of these things would improve the position of the line-of-sight equipment in comparison to the tropospheric scatter system. However, soon the economics of the situation would come into play and the line-of-sight equipment would become much more expensive than tropospheric scatter equipment for performing the same service.

Considerably more information needs to be known on fading range as a function of distance, detailed antenna patterns, propagation loss versus distance, etc. However, the results should be encouraging for tropospheric scatter propagation in pipe line communications systems where circuit lengths in excess of 70 or 80 miles are required.

REFERENCE

[1] K. A. Norton, P. L. Rice, and L. E. Vogler, "The Use of Angular Distance in Estimating Transmission Loss and Fading Range for Propagation Through a Turbulent Atmosphere Over Irregular Terrain," Proc. I. R. E., October, 1955.

ACKNOWLEDGMENT

From a paper presented at the meeting of the Petroleum Industry Electrical Association, May 1-3, 1956, Dallas.

Rules of Thumb

FOR THE PIPELINER'S NOTEBOOK

$15 Per Rule of Thumb

These formulae from the pages of engineers' own notebooks yield rough, but reasonably accurate answers for design, maintenance and supply questions. The Editors will pay $15 for your pet Rule of Thumb. Send your Rule of Thumb to PIPE LINE INDUSTRY, P. O. Box 2608, Houston 1.

Engineering Design

—27—How to determine the maximum surge pressure in liquid-filled pipe line when a main valve is closed suddenly.

The maximum surge pressure that occurs in a crude or products line when a main line valve is suddenly closed may be quickly determined using the simple rule of thumb:

Line pressure equals .8 times the weight of liquid per cubic foot times its velocity in feet per second.

This saves considerable calculation required in using the standard equation:

$$P = \frac{12\, w\, V \sqrt{\frac{32.2}{w}\left(\frac{1}{\frac{1}{K}+\frac{D}{tE}}\right)}}{144 \times 32.2}$$

where P = surge pressure, psi
w = weight of liquid per cubic foot, lbs.
V = velocity change, fps
K = bulk modulus of the liquid, psi
D = outside diameter of pipe, inches
t = pipe wall thickness, inches
E = Young's modulus of the pipe material, psi

Example: A products line transports gasoline at 4.5 feet per second in an 8-inch line. Suddenly the main line valve is closed. Assuming the weight of gasoline to be 45 pounds per cubic foot, what would be the maximum surge pressure to be expected in the system?

Using the simplified equation, $P = .8wV = .8 \times 45 \times 4.5 = 162$ psi. Using the standard equation, P = 159 psi.

Using the Rule of Thumb the error is less than 2 percent.

For more data on advertised products, use Readers' Service Cards, last page.

Even with the increasing use of automatic controls, the most valuable pipeliner is still the effective leader. To help you do your job better, here are . . .

25 Tips from Top Supervisors

MEN ARE STILL important in the operation of modern pipe lines despite increased use of automatic controls. The biggest job of every foreman and leader is to get the continued and whole-hearted cooperation of the men working under him. In the past the supervisor who got the most done was often the iron taskmaster. That day is gone.

In our times it takes many skills, ideas and plans for the modern supervisor to fill the role successfully. He must constantly search for methods of procedure which will assure maximum return from payroll dollars spent by the company in his department.

Getting the job done becomes more complicated, requires added strategy and the use of every possible method developed in business today. Recently 25 successful supervisors were asked about their pet methods of getting maximum results from the men and women under them. Here, in brief form, are their answers.

1. Don't be a watchdog

My job is to get things done through people and I never let myself forget it; every step I take is planned toward that goal. The hardest thing I had to learn was that I was not a ringmaster or watchdog over the people in my department. When this clear understanding of my real role as a supervisor came to me results were better and my work was made a lot easier.

2. Give full credit

The most important one thing that has enabled me to get more done in my particular department is, I am sure, a rule of my own which calls for me always making sure that every man gets full credit for any job well done. I've found that the surest way to discourage initiative and extra effort on the part of the people under you is to overlook such things. Even where we have a bonus for such work I've found the men are just as eager for the recognition of what they have attained as they are for that bonus.

3. Lead, don't force

I try to lead rather than force my people to do the job. Whenever a difficult task comes up I've found it cleared away much faster when I stepped in and took the lead rather than pointed it out and told the men to get the job done themselves. It always results in any given job being performed in far less time than under the old method.

4. Never hurt a man's pride

The biggest thing I've learned in being a supervisor is that you have to be constantly on guard to make sure you never hurt any employe's pride. Sure, you can hire the kind of people who have little pride and are never affected by anything you may do BUT they're not the kind of employes who make any supervisor's job easier for him. Pride is a mighty important ingredient in any worthwhile worker—guard it with care and caution.

5. Treat each person as an individual

The one thing I use to keep my department operating smoothly that I think is of most importance is that I keep studying each man and woman to make sure what particular incentives affect that individual the most. I doubt there are any two alike. When I've found the one which gets top results from any individual then I know how to handle that employe. It sometimes takes several weeks to discover what it is but after that there's a lot of smooth sailing.

6. Explain everything

One thing I've found mighty important is to explain everything. Just telling a man to do something or taking it for granted that he understands all about the problem causes a lot of extra make-up work afterwards and sometimes costly slow downs.

7. Set the example

I set the example I want them to follow. No department in any company is any better than the example set by the supervisor. If he takes a sloppy attitude toward the job his men can't help but follow suit. If he sets an example of initiative, love of his work, interest in every job, etc.—his men will always follow suit.

8. Weigh what you say

I've found the most important single thing in getting the job done is to be extra careful of what you say and how you say it. When you do that your words will mean something to the people toward whom they are directed. By doing this you also cut down possibilities for misunderstandings and mistakes.

9. Promote friendly competition

My chief policy is to promote a competitive spirit among the men in my department. Competition always makes for better results even if for nothing

more than to see who can keep his work the cleanest, turn out the least number of errors, or some other element strictly between the men themselves. One word of caution—make sure that's not belligerent competition.

10. Be a good listener

To me it's most important that a supervisor learn to be a good listener rather than completely dominate every conversation he has on the job with the men under him. When you are a good listener you draw your men out—get them to thinking more about the work, developing their own ideas and taking a greater personal interest in the job.

11. Don't play favorites

To me the big thing in getting the job done is in keeping a smooth running operation. I've found one sure way to assure that, is to bend over backwards to avoid playing favorites. Then everyone on the staff works better with the other fellow on the job.

12. Stop trouble before it starts

I try to locate troubles before they break out. Just about 25 percent of my time is spent doing this. Experience has taught me it's a lot easier to patch up something before it comes to the surface than to clean up after it has boiled over.

13. Don't gripe

I always keep a favorable attitude toward the company. What gripes I have against the front office I keep to myself. I've noticed that where supervisors air their dislikes in front of their men the efficiency drops right there and soon the whole group is doing the same thing.

14. Learn patience

Patience is the greatest asset any supervisor can have in handling any man or any problem. Until he learns patience he can't call himself a good foreman. With it you never make snap judgments.

15. Be fair

The toughest job any supervisor ever faces is in disciplining one of the employes under him. It's a point at which he can start a chain reaction which will lead to an explosion of future trouble for him. I make sure I have all of the facts before I ever discipline any employe. That's kept me from making mistakes which could have disrupted my whole department later on.

16. Praise good work

My pet method of getting the job done is to find every opportunity I can to praise individual employes for their work. It accomplishes wonders. But it can be dangerous if overdone; you have to learn the proper balance and adhere to it.

17. Avoid prejudice

I'm careful to avoid prejudice against any individual employe. If he has feelings, traits or actions I dislike I ignore them completely as long as that individual does a good job. I've seen too many cases where supervisors let prejudices against certain employes ruin all of the other good things they have done and completely mess up their departments.

18. Build the man's job

To me one of the most important things you can do is to never overlook an opportunity to build up a man's job in his own estimation. The man who is proud of his job always does more for you with less trouble.

19. Accentuate the future

I keep building on each employe's future with the company. I've found the men under me have to have goals toward which to work hard; without them they never have the incentive to do anything extra. I never overlook an opportunity to do this.

20. Avoid destructive criticism

A supervisor has to dish out criticism; that's one of the reasons he's in his job. But I've found there are two ways to do it, i.e., constructively or destructively. The former gets the best results. Whenever I criticise my employes it's done constructively . . . and I've always had good results with this approach.

21. Show appreciation

Show an interest in and appreciation of his work; that makes him a better man and easier to handle. Confine your efforts to keeping him working and he'll use every dodge he can think of to keep from doing anything extra.

22. Discuss job problems

My pet rule is to always discuss every job problem with the men involved. Following it has done more for me in my department than anything else I've ever tried to do. You get more willingness to do something extra from your men when they have a chance to help you work things out.

23. Stress individual initiative

One of my pet methods of getting the job done in my department is to give my men things to work up on their own. That keeps them from being mere machines. It keeps them alert. It enables them to have that something extra when they have to think out a problem all by themselves during an emergency.

24. Don't make false promises

I carefully avoid making promises that I may not be able to fulfill. I've found that's a bigger source of resentment by employes against their supervisors than anything else. When it involves the company I make sure first it will be delivered before I promise my men anything.

25. Be consistent

I try to be consistent in my approach to all of the problems concerned with my department. I've found the men are then never afraid of my moods or uncertain about what I will do. It also helps them work out a lot of problems on their own.—**TheEnd**

Who Read Your Last Report?

Writing technical reports that will be read is easy . . . if you follow these simple, common-sense rules.

By W. B. ETHERIDGE
Columbian Carbon Company, Conroe, Texas

"EVEN A HARVARD economist is glad to have his time saved by good, clear English." So states Bernard Kilgore of the *Wall Street Journal.*

Speaking of readable writing, how do you write a letter to a friend? Did you ever give that friend one of your reports? What was his response? None? (P. S.—He probably didn't read it.)

For that matter who *did* read your last report? Did the boss take it home to read in bed?

In that report did you mention a "permit facilitating acquisition of" or did you just say "permit to buy"?

Using simple language is good sense.

After a glance at the front page of your afternoon paper, you dive for the comics. They are written in a "spoken language." So are the sports pages, too, usually. They have short sentences—an idea or two at a time.

Dialog will help your report. Use it.

Active verbs and shorter words—Use active verbs to keep writing lively. "John hit the ball" gives you a picture and more sparkle and creates more interest than "The ball was hit by John." Or, more technical, "The pen marked the chart," instead of "The chart was marked by the pen."

Or, "I closed the control damper," instead of "The control damper was closed by the writer of this report." (Your reader may forget who wrote the report before he gets that far if you make it too impersonal.)

Don't leave out all the long words. If they express your exact meaning, use them. They are the spice in the pudding.

Don't make your mixture of long words too lean—you must add some gas to the air in your car's carburetor. Be sure the word is clear to you. Be sure the word is clear to your audience! If you have to stumble through a dictionary to find the meaning of a word, think thrice before using it.

Avoid long paragraphs. Breaking up your writing into short paragraphs makes for easier reading.

Words are like women. They are necessary, but when you get too many of them together, confusion results.

A favorite wordy expression in many of our reports is "each and every engineer." Why not "all engineers," or "each engineer?" Do the extra words tell you anything?

To do the best job, the expert uses the right tool.

Watch that punctuation! Punctuation is an important tool. Correct punctuation may mark you as an amateur or a professional:

"Mr. Jones," said the teacher, "is a fool."

Mr. Jones said the teacher is a fool.

These are the same words but the tools are used differently, with different results.

An old standby of typists is "Look at this spelling. Some engineer must have written it." Bad spelling need not be the trademark of engineers. Spelling can mark YOU. Be sure it is a good mark.

Thirty years ago spelling was mastered by a sixth-grade student. Today, some college graduates have not mastered it.

Will your audience dictate that you "go foot," or that you should stand at the head of the line? Generally, good spelling makes sense.

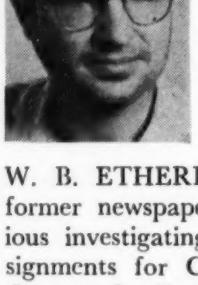
Rules are the life of an engineer—physical laws, chemical laws, natural laws—and without them he could not interpret, predict, or even read and understand results. A few more rules which may profitably be added are those of basic English. How to divide the word. How to add "ing." How to use the apostrophe—*Its* or *It's* never too late to learn?

A recent discussion among a group of engineers was how to add "ing" to age. Out of nine persons asked, four were sure the "e" should be left in.

THINK BEFORE YOU WRITE.
THINK BEFORE YOU TALK.

Get yourself organized—The birth of a good report should begin with a period of thought with the object of "Just what do I want to tell my readers?" Make notes. Organize a plan of presentation.

If the discussion of your report covers construction of a building, lay the



About the Author

W. B. ETHERIDGE, lawyer and former newspaperman, handles various investigating and reporting assignments for Columbian Carbon Company's Carbon Black division, which operates a plant at Conroe, Texas. This work, which he has been carrying on since 1943, is in addition to his legal practice at Conroe. Etheridge is a journalism graduate from the University of Texas and holds a law degree from South Texas School of Law.

foundation before you put on the roof. Keep your details and statements in a logical sequence in a discussion.

There is the story of the cub reporter who was sent out to cover a big society wedding. He failed to return to the office or phone in a story. Next morning, he was questioned.

"Oh, there was no wedding," he said. "The bride was run over and killed in front of the church and the groom collapsed and was carried to the hospital," he explained.

Perhaps some very important result happened which was not directly connected with your experiment. This may make a separate and more important report—or eliminate the one you at first proposed to write. THINK, then write.

Work from an outline—be neat! Quality in typing and preparation gives your reader his first impression of your report. Don't hesitate to have a page retyped to make needed corrections.

Ask your typist to use the front of the paper, not the back. She can watch the watermark.

A good outline for a report is

Introduction. Give the purpose of the report and describe the test or process being reported.

Summary. What happened that you are telling about?

Conclusions. What were the results?

Recommendations. How do you think the process could be improved? What changes should be made?

Discussion. How was the test performed? What happened?

Appendix. Insert your charts and other exhibits here if they are for possible reference only. If they fit in closely with the discussion, insert them with it.

Use these headings for all except short reports in which the parts are obvious to the reader—as, one-page reports.

A table of contents is a general outline of the report by headings and page numbers. An index is specific. A long, involved report should have both. Short reports need neither, but a table of contents will help set out the 8 or 10-page report as a work of art. It may distinguish you from an amateur. —The End

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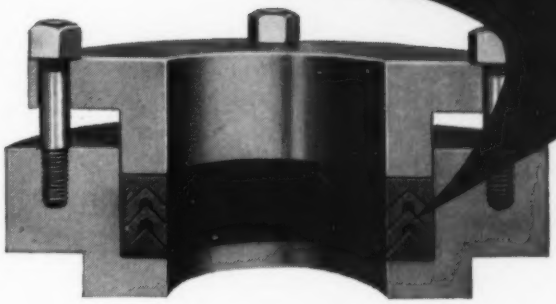

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tightens as pressure increases, eases off as pressure decreases, assuring no-leak sealing and minimum friction on rams, plungers, reciprocating rods, etc.

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- On hydraulically operated clutches with ¾" cylinder, 500 psi pressure, ¾" travel, operating intermittently. Neither leather cups nor "O" rings worked well. Now packed with GARLOCK 431 CHEVRON ⅜" x ¾" x 17/32" deep. Result: smooth, positive sealing.

And remember, 431 CHEVRON Packing is only one of "the famous GARLOCK 2,000" . . . two thousand different styles of packings, gaskets, and seals to meet *all* your needs. It's the *only* complete line . . . it's one reason you get unbiased recommendations from your GARLOCK representative. Call him today or write for Folder AD-115.

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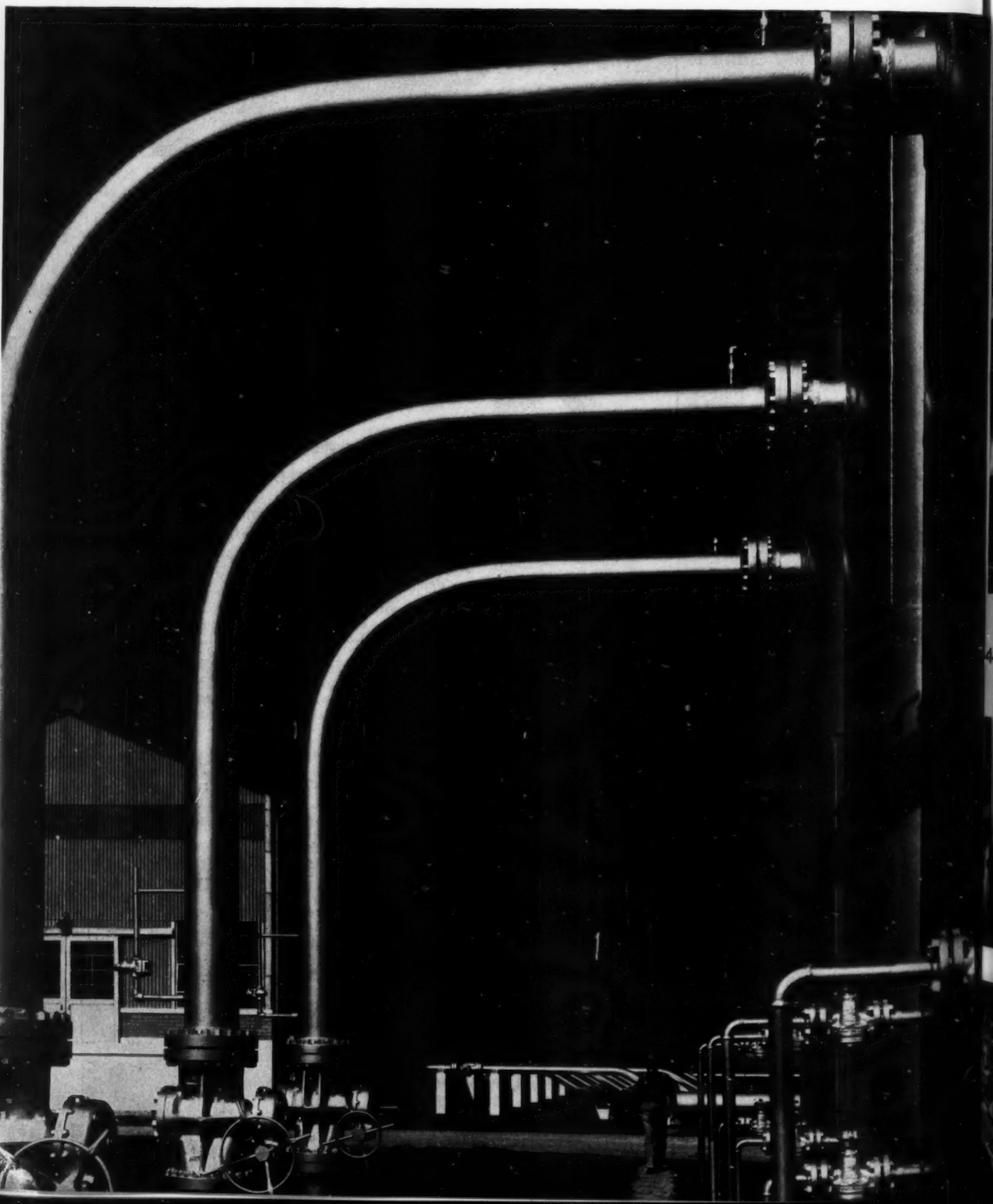
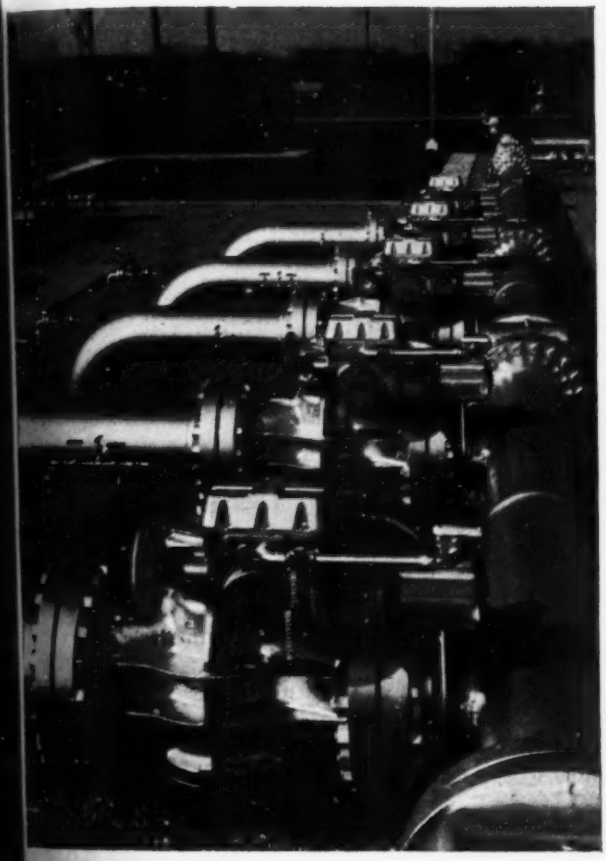
ROCKWELL-Nordstrom **VALVES**



Profitability

Keep pipelines profitably on stream



Valve down time often plays a large part in the profitability of gas, petroleum and products pipelines. Years of exceptional performance records and cost studies prove that Rockwell-Nordstrom valves are the best way to keep profitably on stream. Here are three reasons why you see so many Rockwell-Nordstrom valves on so many pipelines:

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Rockwell-Nordstrom valves are available in a complete range of sizes and pressure ratings in steel, semi-steel and corrosion resisting metals. For more information, see your nearest supplier or write: Rockwell Manufacturing Company, Pittsburgh 8, Pa.

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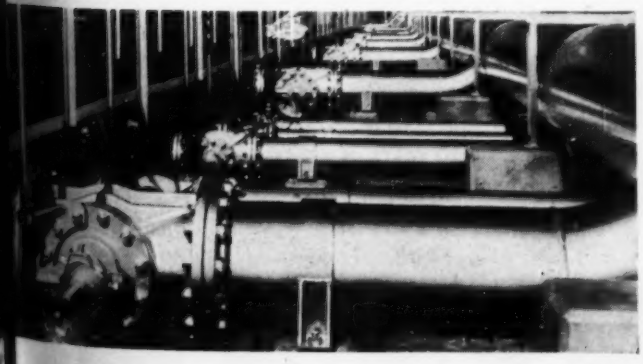


Trans-Canada Construction Near Pending Vote on Government Loan

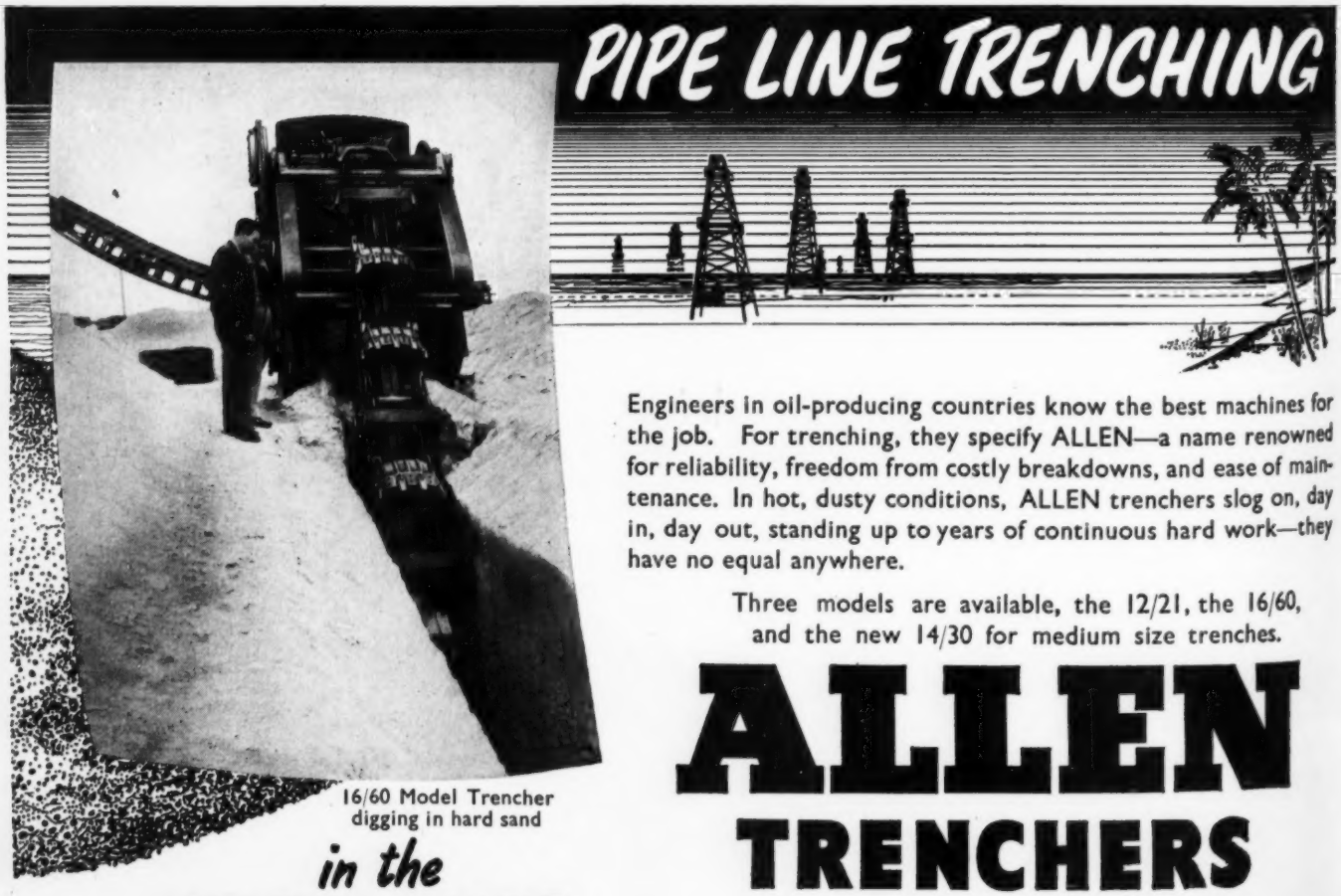
If the Canadian Parliament completes debate and agrees by June 7 to lend Trans-Canada Pipe Lines Ltd., $72 million to finance the first leg of the 2250-mile natural gas line from Alberta's gas fields to eastern Canada, construction on the long-proposed pipe line is expected to begin in July.

The proposal to lend up to 90 percent (or $72 million, whichever is the smaller amount) of the cost of the 575-mile line from Alberta to Winnipeg was accepted by the Cabinet and is being debated by the Parliament. Trans-Canada has pledged all its assets to repay the loan at 5 percent interest by March 31, 1957. In the event these terms are not met, the Canadian government can take over the project. Trans-Canada will put up $8 million of the construction cost plus any excess of the total cost over $80 million.

If the loan is repaid on time and Trans-Canada is then in a position to construct the line east from Winnipeg, the government agreement covering construction of the northern Ontario section by the Crown Corporation will take effect. Under this plan, the Crown Corporation will construct the 675-mile line from the Manitoba border to Kapuskasing, Ontario, and Trans-Canada will construct the line from Winnipeg to Montreal. The Northern Ontario section will be financed by the provincial government of Ontario and the government of Canada. Total cost of the 2250-mile line is estimated at $350 million.

The proposed government loan to Trans-Canada for the first leg of the line came after Frank McMahon, president of Westcoast Transmission Company, made an offer to build the line with private capital and later withdrew his offer, explaining that Trans-Canada was in the preferred position to build the line soon. McMahon was backed by others believing that the line should be built by Canadian capital.

June 7 is deadline date for approval of the government loan in order that Trans-Canada can begin construction. The 34-inch line from Alberta to Winnipeg is expected to be completed by November 1 if construction gets underway in July. Failure to complete this line this year will cause Trans-Canada to lose the line. Preliminary engineering work has been done and enough pipe for this section has been delivered to rail points or is on order for delivery soon. Construc-



16/60 Model Trencher digging in hard sand

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tion is expected to proceed rapidly across the prairie sections.

Several other projects, including the $52 million gathering system to be built by Alberta Gas Trunk Line Company, Ltd., depend on the success of the government loan plan.

The proposal of Tennessee Gas Transmission Company and its affiliate, Midwestern Gas Transmission Company, to build a 1112-mile line and sell Canadian gas through the Midwest is still before the Federal Power Commission. Trans-Canada has contracted to sell TGT 200 million cubic feet of gas daily at Emerson, Manitoba. TGT and Midwestern are seeking a permit from the FPC to import this gas.

Imperial Oil Lets Contract For 38-Mile Products Line

Imperial Oil Limited has awarded a contract to Majestic Contractors Ltd. of Edmonton to lay 38 miles of 12-inch pipe parallel to the present line from Waterdown to the company's new terminal in North Toronto. Construction is to begin in July and will be completed by September.

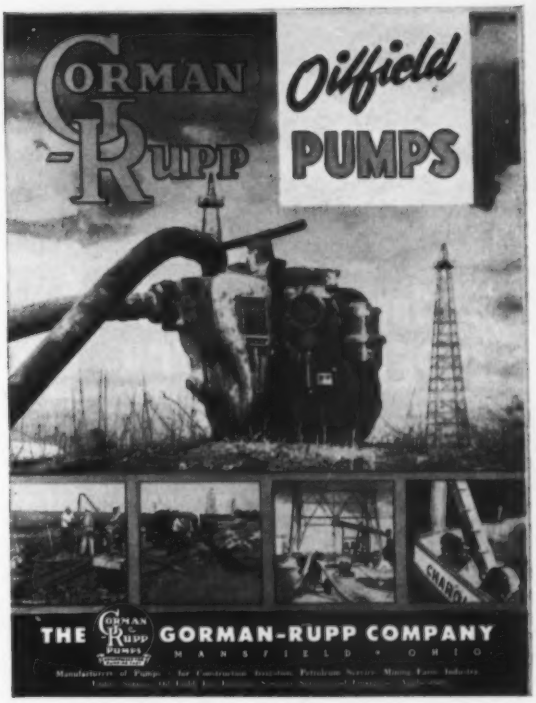
Pacific Northwest to Build 50-Mile Line in Colorado

Pacific Northwest Pipeline Corporation has received Federal Power Commission authorization to construct and operate 167.9 miles of lateral pipe line in Washington and 50 miles of new pipe line in Colorado.

The 50 miles of new line in Colorado, estimated to cost $1 million, will be built to serve two direct industrial customers, Union Carbide Nuclear Company at Uravan, Colo., and Vanadium Corporation of America at Nucla, Colo. It includes 36.7 miles of 6⅝-inch line from Dove Creek, Colo. to Nucla and 13.3 miles of 4½-inch from Nucla to Uravan.

The Walla Walla lateral consists of 31 miles of 6-inch costing $672,160. The Yakima-Wenatchee lateral, costing $4 million, includes 71.1 miles of 10-inch, 62.7 miles of 8-inch and 3.1 miles of 6-inch.

Temporary authority was given to Pacific Northwest in March to construct the facilities but not to place them in operation. The FPC at that time also permitted the company to increase the sizes of previously authorized pipe to be used in the Walla Walla and Yakima-Wenatchee laterals.



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American Louisiana Receives Approval to Operate Gas Line

American Louisiana Pipe Line Company has received Federal Power Commission authorization to operate its Louisiana-to-Michigan natural gas transmission system, now nearing completion. The order also allocates temporarily the entire 300 million cubic feet daily of initial delivery capacity to two affiliates, Michigan Wisconsin Pipe Line Company and Michigan Consolidated Gas Company.

The FPC also authorized American Louisiana to construct and operate a 117-mile line from Payne, Ohio, to Bridgman, Mich., to provide a connection between the main lines of American Louisiana and Michigan Wisconsin. It is estimated to cost $7.8 million.

Michigan Wisconsin received authorization to construct 252 miles of line and 3400 additional compressor horsepower on its system, at an estimated cost of $11 million.

Of the capacity allocated, only 135 million cubic feet of the gas for Michigan Consolidated was made on a permanent basis, and 85 million cubic feet was permanently alloted to Michigan Wisconsin. The FPC reserved decision on the permanent allocation of the remaining 80 million cubic feet pending the outcome of proceedings on requirements of other distributing companies in Illinois, Wisconsin and other areas which are seeking gas service from American Louisiana or Michigan Wisconsin.

Inland Natural Gas Proposes 320-Mile Line in Canada

Inland Natural Gas Company is seeking approval from the Public Utilities Commission of British Columbia for a proposed $24 million natural gas line and distribution system for the interior of British Columbia. Federal and provincial governmental approval have been received.

The 320-mile line will tap Westcoast Transmission Company's trunk line at Savona, 20 miles north of Kamloops. It will cut through the Cariboo, Okanagan and Kootenay districts and will serve such inland cities at Prince George, Kamloops, Nelson Trail, Vernon, Kelowna and Penticton.

The company plans to begin construction in spring using 6-inch to 12¾-inch pipe.

Do you keep
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—every time you start one of your gas engine driven compressors? Many a starting air piping system has been blown into shrapnel by a lubricating oil vapor explosion. The possibility of this can be obviated by installing a Campbell Centrimpact separator. Price, $300.00, f.o.b. Long Beach, California. This is *not* a filter but a combination of centrifugal and impact design which throws out the finest mist particles and isolates them from the flow. We can state without fear of contradiction that CENTRIMPACT IS THE MOST EFFICIENT MIST EXTRACTOR EVER BUILT.

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The "Muskrat Line", with its feeders, covers a total of 355 miles. From point A, off the Louisiana Coast, it runs generally westward across the Mississippi River Delta and along the Louisiana coast. And at point B (Crowley, La.) it hooks up with the existing gathering system. Only the last 70 miles of the line, before it reaches Crowley, involved normal dry land construction techniques.

New 355-mile pipe line extension gets colorful name from wild swamps and marshlands it traverses. *Four-fifths of it will be laid under water.*

THE "Muskrat Line" extension is part of this company's current $56,000,000 pipe line and compressor expansion program. When completed, the program will give the Tennessee Gas system a total of more than 9500 miles of pipe line in 15 states. Average daily delivery capacity will then be 1,800,000,000 cubic feet.

A. O. Smith Corporation is proud to be a part of this new extension by furnishing the 18 and 20 inch and a portion of the 24-inch line pipe.

The purpose of this new construction is to bring important new onshore and offshore natural gas reserves to the customers of Tennessee Gas.

The magnitude of the work involved in building the "Muskrat Line" is indicated by the facts that special canals had to be dredged through the marshlands . . . special pipe-laying barges had to be built . . . and 130 navigable bodies of water had to be crossed. Completion of the "Muskrat Line" is expected by mid-summer.

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Creole to Build 128 Miles Of Crude Lines in Venezuela

Creole Petroleum Corporation will build two new crude oil pipe lines as part of a general expansion program of the company's crude loading facilities in Lake Maracaibo, Venezuela.

Creole will build a 16-mile 34-inch crude line from Bachaquero to Lagunillas costing $2 million, a 94-mile 28-inch line from Temblador to Caripito costing $5.6 million, and a new pumping station at Lagunillas. These projects are planned in conjunction with the recent dredging of a 36-foot deep channel in the mouth of Lake Maracaibo, enabling supertankers to depart from the Lake with a full load.

The Temblador-Caripito line will carry 30,000 barrels daily by the end of 1958, increasing thereafter. New island terminals are planned for La Salina with an eventual daily capacity of 750,000 barrels. The 1956 budget includes $17 million for dredging, steel piers, island terminals, four tanks with a capacity of 268,000 barrels each, two 750,000-barrel concrete reservoirs, submarine lines, engineering and miscellaneous items.

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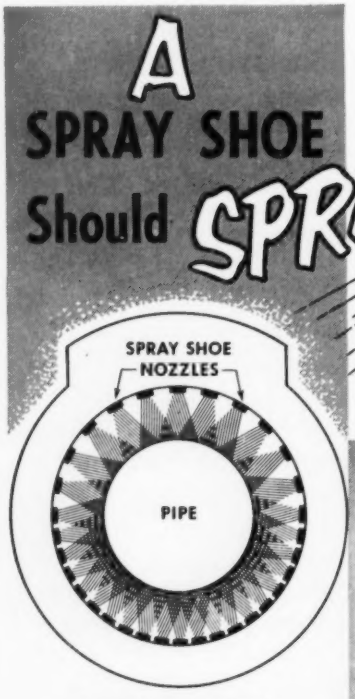
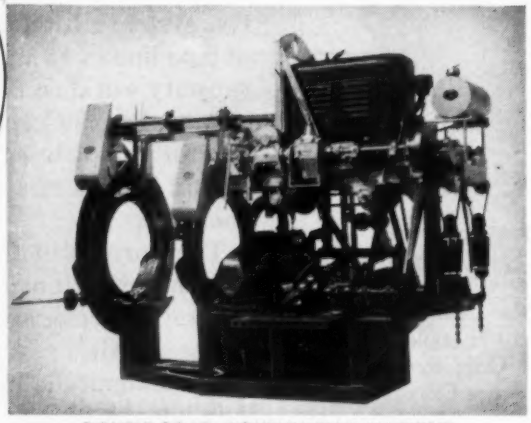


Spray shoe cross section shows how spray nozzles give DOUBLE dope coverage on pipe top, TRIPLE coverage on pipe bottom . . . Insurance for a better coating job.



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Transco Application to FPC Covers 277-Mile Project

An application by Transcontinental Gas Pipe Line Corporation for authority to construct 277 miles of pipe line and facilities costing $42.3 million has been accepted for filing by the Federal Power Commission.

The project includes 160 miles of 36-inch pipe, 68 miles of 30-inch and 24 miles of 24-inch pipe to be laid in 1956 in Louisiana, Mississippi, Alabama, Georgia, South Carolina, North Carolina, Virginia, Maryland and Pennsylvania. (See PIPE LINE INDUSTRY, April 1956, page 62.) The application also covers 25 miles of 36-inch to be constructed in 1957.

A total of 12,750 horsepower units at various compressor stations, additional facilities at existing compressor stations, river crossings on the James and Susquehanna rivers and various distribution meter stations will be included in the construction. Work is expected to begin in July, pending FPC approval.

Permian Basin to Increase Compressor Station Units

Permian Basin Pipeline Company has requested Federal Power Commission approval to add five additional units to its proposed Andrews County, Texas, natural gas compressor station. The proposed addition, estimated to cost $1.2 million, increases the station horsepower rating to 13,500 and enables Permian to transport 50 million cubic feet of gas daily.

Permian recently received authorization to build a 19-mile 16-inch pipe line and a 6750-horsepower compressor station to transport an additional 25 million cubic feet of gas daily.

Kansas-Nebraska Plans New Facilities in Nebraska

Kansas-Nebraska Natural Gas Company has applied for Federal Power Commission approval of a $1 million pipe line construction project in Nebraska.

The company plans to install 32.7 miles of line and additional compressors at five locations, increasing the compressor stations capacity by 2700 horsepower. The proposed facilities will serve increased demands of existing markets in Nebraska.

This construction, along with facilities which the company says are not subject to FPC approval, will cost approximately $4 million.

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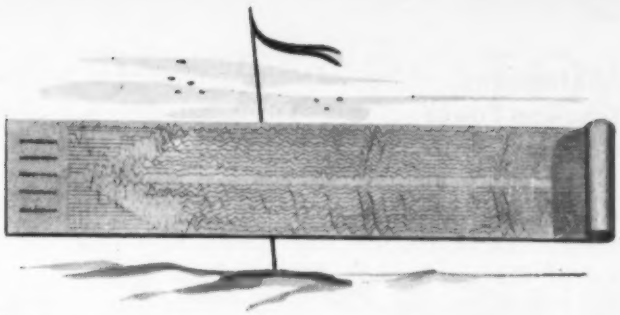

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As geophysical activity has increased and become more effective, SIE has paced the industry by developing new equipment and methods. Today SIE seismic systems, magnetic recording systems, geophones, recording oscillographs, precision galvanometers, radios and other electronic instruments are serving the oil industry in every major field in the world. SIE adds electronic instrumentation to the broad application of Dresser *plus+* equipment and services.

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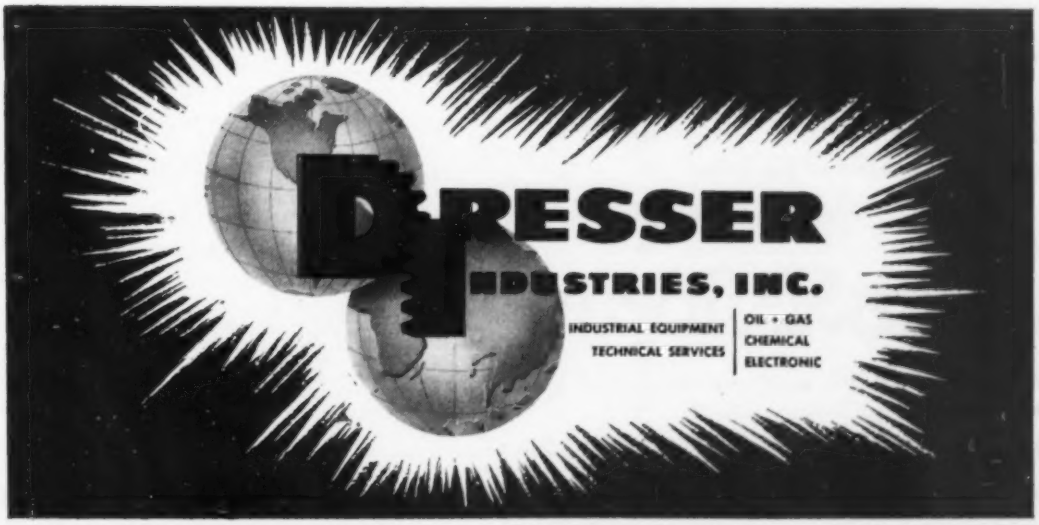

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Contracts for Extensions Let by Saskatchewan Power

Saskatchewan Power Corporation has announced that contracts for construction of natural gas extensions have been awarded to Banister Construction Limited of Saskatoon and Edmonton, Fulton-Banister Company of Edmonton and Marine Pipeline and Dredging Limited of Vancouver.

Fulton-Banister will construct a 120-mile pipe line from Success to Moose Jaw, an extension to the Hoosier field and a gathering system at that point, a 16-mile line from the Brock field to Eston, and a transmission line from Biggar to North Battleford and from Dana to Humboldt.

Banister Construction will build the Moose Jaw, Swift Current and Eston distribution systems as well as distribution systems in the smaller towns and villages being served this year. The Battleford and North Battleford distribution systems will be built by the Marine Pipeline and Dredging Limited.

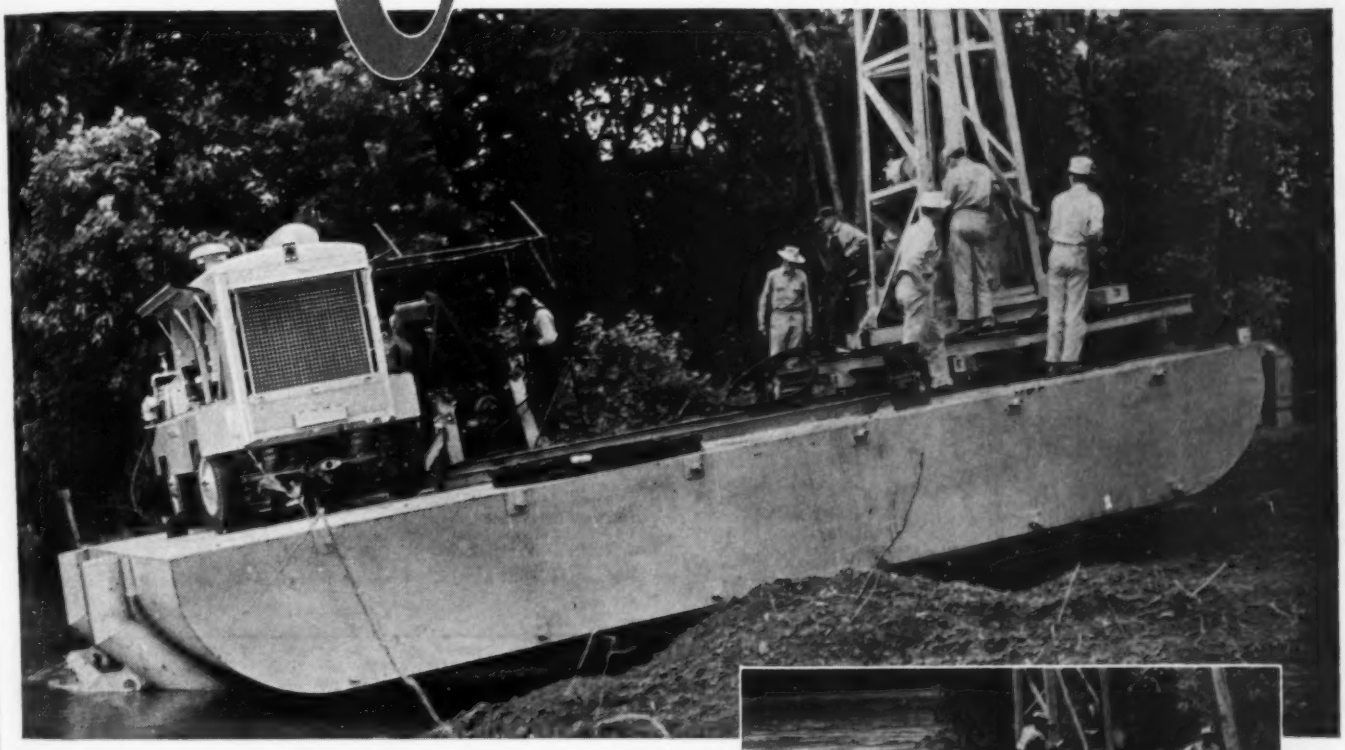
Proposed Pipe Line Construction

COMPANY	Length in Miles	Diameter	Type	Origin and Terminus	Estimated Cost	Status
Alberta Gas Trunk Line, Ltd.	547	6-34	Gas	From Alberta fields to western terminus of Trans Canada Pipe Line, Ltd.	$47 million	Approved
American Louisiana Pipe Line Company	117	....	Gas	Payne, Ohio to Bridgman, Mich.	$7.8 million	Authorized
Atlantic Seaboard Corporation	86	20, 26	Gas	In West Va. and Va. paralleling sections of the company's existing line and extending from Seabcard's Lost River compressor station to its Bickers compressor station interconnecting the company's lines.	$8.5 million	Authorized
Bolivian Gulf Oil Co.	201	....	Crude	Sicasica, Bolivia to Arica, Chile	.....	Planned
Central Kentucky Natural Gas Co.	24	20, 24	Gas	Cold Springs—Anderson Ferry, Ky.	$2.5 million	Authorized
Chaco Pipeline & Refinery Corp.	450	....	Products	From Glenn McCarthy's Bolivian wells to new refinery at Conception, Paraguay	.....	Planned
Cities Service Gas Co.	15.5	16	Gas	Various locations in Kansas and Oklahoma	.....	Planned
Coastal Transmission Corp.—Houston, Texas	565	20-26	Gas	McAllen, Texas—Louisiana connection, Houston, Texas Gas, plus 272 miles of laterals	$68 million	Before FPC
Colorado Interstate Gas Co.	380	22	Gas	Green River, Wyo.—Denver	....	Contract let
	800	16-30	Gas	Laramie, Wyo. to Beatrice, Neb. to deliver gas from Rocky Mountain area and Texas and Oklahoma Panhandle fields to Natural Gas Pipe Line Co. of America	$76 million	Before FPC
Compania Shell de Venezuela	177	20	Gas	La Paz field to Cardon refinery on Paraguana peninsula	$20 million	Planned
Consolidated Gathering Systems, Ltd.	198	....	Crude	Sturgeon Field—Edmonton.	.....	Planned
Consolidated Natural Gas Corp.—New York	112	....	Gas	In Ohio—Plus other smaller lines	$6 million	Planned
Creole Petroleum Corp.	16	34	Crude	Pachaquero to Lagunillas, Venezuela	$2 million	Planned
	94	28	Crude	Temblador to Caripito, Venezuela	$5.6 million	Planned
Deep Rock Gas Co.	120	6	LPG	Tioga, N.D.—Canadian border	.....	Planned
El Paso Natural Gas Co.—El Paso, Tex.	338	34	Gas	Parallel from San Juan Basin to Topock, Ariz.	$194 million	Contract let
El Paso Natural Gas Products Co.	240	8	Products	Midkiff natural gasoline plant in Permian Basin to El Paso	.....	Planned
Houston Texas Gas & Oil Co.,—4604 Main St., Houston	961	12-30	Gas	Baton Rouge, La. to Miami, Fla. plus 496 miles of laterals and compressor facilities	$105 million	Before FPC
Hydro-Carbons Pipe Line, Ltd.	800	....	LPG	Edmonton to Winnipeg with gathering system and storage	$35 million	Planned
Imperial Oil, Ltd.	38	12	Products	Parallel existing line from Waterdown, Ont., to North Toronto terminal	$1.7 million	Contract let
Inland Natural Gas Co.	320	6-12	Gas	To tap Westcoast Transmission's trunk line at Savona, British Colombia.	.....	Planned
Interprovincial Pipe Line Co.	150	20	Crude	Sarnia, Ont. to Toronto, Ont.	.....	Planned
Iron Ranges Natural Gas Co.	115	....	Gas	From Itasca and St. Louis Counties along route of Mesabi range from Grand Rapids to Aurora, Minn.	$5 million	Before FPC
Kansas-Nebraska Natural Gas Co.	32	....	Gas	Facilities in Nebraska	$4 million	Before FPC
Magna Pipeline Company	40	....	Gas	Underwater line from Anacortes, Wash. to Victoria, B.C.	$6 million	Planned
Malco Pipe Line Inc.	91	6	Products	Prewitt, N.M.—Albuquerque	$1,250,000	Considered
Michigan-Wisconsin Pipe Line Co.—500 Griswold, Detroit	472	4-24	Gas	Main line loops and extensions in Wisconsin, Illinois and Michigan	$17.6 million	252 miles authorized
Midwestern Gas Transmission Co., Houston, Texas	1112	....	Gas	Emerson, Manitoba—Nashville, Tenn.	$98 million	Before FPC
Montana-Dakota Utilities Co.—Minneapolis	44	....	Gas	Various locations in S.D. and Wyoming	$1.4 million	Authorized
	41.8	12	Gas	Williams County, N.D.	$1.4 million	Authorized
Mountain Fuel Supply Company	38	20	Gas	Parallel line and facilities to transport gas from Pacific Northwest line in Sweetwater County, Wyo.	.....	Planned
NATO	1920	4-10	Products	To serve military bases in Western Europe	.....	Foster-Wheeler Prime Contractors, 1330 miles let
Natural Gas Pipe Line Co. of America—20 N. Wacker Dr., Chicago	350	20, 26	Gas	Wise County, Texas—Fritch, Texas	$28.5 million	Authorized
	480	30, 36	Gas	Loops at various points along existing line	$80 million	Before FPC
New York State Natural Gas Corp.	27	....	Gas	Elk County, Penn. to Luthersburg gas field in Clearfield, Jefferson and Indiana Counties, Penn.	$1.5 million	Authorized
North Carolina Natural Gas Corp.	575	3-16	Gas	Mooresville eastwardly across North Carolina	$13 million	Authorized
Northern Natural Gas Co.—2223 Dodge St., Omaha	167	24	Gas	Farmington, Minn. to Duluth, Minn. and Superior, Wis.	$12 million	Before FPC
	....	....	Gas	To interconnect with Natural Gas Pipe Line	$244,000	Planned
	28.4	30	Gas	Test lines to underground storage near Redfield, Iowa	$4.8 million	Before FPC
Offshore Gathering Corp., Houston	364	24, 26, 30	Gas, Crude	Texas side of Sabine River 25 miles offshore La. to Mississippi side of Pearl River	$150 million	Before FPC
Pacific Gas & Electric Co.	150	34	Gas	Various loops, between Topock, Ariz.—Milpitas, Calif.	$4 million	Planned
	83	12, 18, 20	Gas	Glenn County areas to Sarcamento region	$5 million	Planned
Pacific Northwest Pipe Line Corp.—M & M Bldg., Houston	1,487	22, 26	Gas	San Juan Basin—Pacific Northwestern states and Canadian border terminus near Sumas, Wash. plus 732 miles of supply and sales laterals	$246 million	Contracts let for main line and 477 miles of laterals
	50	46	Gas	To serve industrial customers at Uravan and Nucla, Colo.	$1 million	Authorized
Pembina Pipe Line, Ltd.	100	....	Crude	Gathering line and new pumping unit in West-Central Alberta	$4.5 million	Planned
Pennsylvania Gas Co.	38	8, 10	Gas	In Erie and Warren Counties, Penn., and Chautauqua County, N.Y.	$930,000	Before FPC
Petroargentina	370	16	Crude	Newguen—Bahia Blanca, Argentina	$40 million	Planned
Petroleos Mexicanos—Ave. Juarez, 94, Mexico City	440	20	Gas	Brazil—Tampico—Poza Rica, Mexico	.....	Planned
	145	12	Crude	18 de Marzo Field—Monterrey, Mexico	.....	Considered
	80	8	Products	Guaymas—Los Mochis	$1 million	Planned
Phillips Petroleum Co.—Bartlesville	54	6	Products	Goldsmith—Borger, Texas	.....	Planned
	22	20	Gas	Roberts County, Texas, to Rock Creek gasoline plant	.....	Approved
Saskatchewan Power Corp.	80	....	Gas	Hatton gas field to Success, Sask.	.....	Planned
	40	....	Gas	Moose Jaw, Sask. to Regina, Sask.	.....	Planned

30" PIPELINE CROSSES POTOMAC

with the aid of a drill-barge-mounted

GYRO-FLO PORTABLE



Unique submarine drill barge, built by Associated Pipe Line Contractors, Inc., is powered by a standard Ingersoll-Rand 600 cfm Gyro-Flo portable compressor

Associated Pipe Line Contractors, Inc., recently completed laying a 30" line across the Potomac River near Rockville, Md. The river at this point was 2800 feet wide with a bed of solid rock.

This difficult rock drilling problem was solved by using the all-steel drill barge shown above, built by Associated. On it are mounted an Ingersoll-Rand SD-65 Submarine Drill which is powered by a 600 cfm Gyro-Flo portable air compressor. The Gyro-Flo is anchored aboard without removing the running gear, thus leaving it available for on-land drilling work.

This river crossing is a part of Associated's 80 mile section of Transcontinental Pipe Line Corporation's main line looping program from Texas to New York. The Gyro-Flo mounted on the barge was only one of a number used on this project, and these compressors, together with other Ingersoll-Rand rock drilling equipment gave their traditional trouble-free performance.

Wherever contractors need dependable, low-cost air power, they agree that "there's only *one* Gyro-Flo". Ask your Ingersoll-Rand representative to give you the complete story.

Ingersoll-Rand

2-396

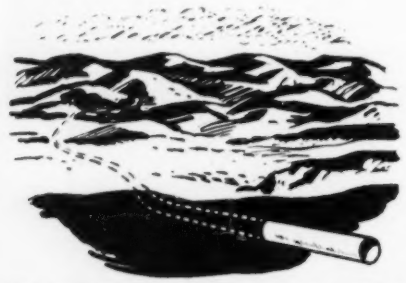
11 Broadway, New York 4, New York

AN UNBEATABLE COMBINATION . . . GYRO-FLO COMPRESSORS AND I-R ROCK DRILLS

For more data on advertised products, use Readers' Service Cards, last page.

Proposed Pipe Line Construction—(Continued)

COMPANY	Length in Miles	Diameter	Type	Origin and Terminus	Estimated Cost	Status
Sinclair Oil & Refining Co. and Socony Mobil Oil Co.	211	....	Crude	San Silvestre field, Barinas, Venezuela, to Puerto Cabello on Caribbean sea coast	$25 million	Planned
South Alberta Pipe Line, Ltd.	46	10	Gas	Etzikom Field—Medicine Hat, Alberta	$1 million	Planned
South Saskatchewan Pipe Line Company	58	12	Crude	Cantuar field to Dollard field, Saskatchewan	$3 million	Planned
Southern Calif. Gas Co. and Southern Counties Gas Co.	278	30	Gas	Topock, Ariz.—Newhall, Calif.	$31 million	Planned
Southern Natural Gas Company	52	....	Gas	Various locations in Ga. and La.	$2.2 million	Authorized
Southern Pacific Pipe Lines, Inc.	....	....	Products	From San Francisco Bay area to Reno—Fallon, Nev. area	$16 million	Planned
Stanmount Pipe Line Co.	140	10	Crude	Cayiga and Beaver Lake Fields, N.D. to connect with Interprovincial Pipe Line	.....	Planned
Sturgeon Pipe Line Ltd.	100	12	.....	Sturgeon Lake Field—Trans-Mountain system	$6,500,000	Planned
Sui Gas Transmission Company	200	16	Gas	Sui field in Pakistan to Multan in southern Punjab	.....	Planned
Sunflower Pipe Line Co.—Tulsa, Okla.	265	3-6	LPG	Kearny, Grant and Haskel Counties, Kansas—Wichita, Kansas	$3.5 million	Authorized
Tecumseh Pipeline Co.	....	20	Crude	To connect to principal crude line carriers in Chicago area for movement to east	.....	Planned
Tennessee Gas Transmission Co.—Box 2511, Houston (See also Midwestern Gas Transmission Co.)	220	26, 30	Gas	Loops in Kentucky and Ohio plus 376 miles of Supply laterals in Texas and Louisiana	$56 million	Authorized
	100	....	Gas	Gathering lines in Texas and Louisiana plus station additions	$18.6 million	Before FPC
	162	....	Gas	Loop Lines in Kentucky, Ohio, and Pennsylvania	$24.3 million	Before FPC
Texas Eastern Transmission Corp.	422	30	Gas	McAllen to Vidor, Texas	Estimated	Before FPC
	530	30	Gas	Loops at various points between Kosciusko, Miss. and Uniontown, Penn.	Cost of Entire Project	Before FPC
	45	24	Gas	Provident City, Texas crossover to McAllen-Vidor line	$150	Before FPC
	135			Supply and delivery lines laterals	Million	Before FPC
Texas Eastern Transmission Corp. and Texas Eastern Penn-Jersey Corp.	....	....	Gas	Additional compressor facilities to system in Penn.	$8.3 million	Before FPC
Texas Gas Transmission Corp.	198	20	Gas	East Lake Palourde Gas field, La. to Eunice, La. and loops paralleling existing system in Arkansas, Mississippi, Tennessee, Kentucky, Indiana	$20 million	Authorized
	40	....	Gas	Parallel lines at various locations in Louisiana, Arkansas, Mississippi, Kentucky, Illinois	$6 million	Before FPC
Trans-Canada Pipe Line, Ltd.—Calgary, Alberta	2240	30, 36	Gas	Alberta—Eastern Canada	$297 million	Planned
Trans Carolina Pipeline Co.	280	4-18	Gas	In tidewater areas of North and South Carolina	$21.6 million	Before FPC
Transcontinental Gas Pipe Line Corp.—3100 Travis St., Houston	....	....	Gas	Connecting facilities with Texas Eastern Penn-Jersey in Pennsylvania and New Jersey	$131,628	Authorized
	24.2	....	Gas	Gathering Lines from South Bayou Mallet, Maxie and Happytown Fields, La.	$754,000	Authorized
	12	....	Gas	Live Oak gas field, Vermillion Parish, La. plus two meter stations	$707,000	Before FPC
	277	30, 36	Gas	In Louisiana, Mississippi, Alabama, Georgia, S. Carolina, N. Carolina, Virginia, Maryland, Pennsylvania	$42 million	Before FPC
United Natural Gas Co.	50	12	Gas	Elk County—Jefferson County, Pa.	.....	Planned
U. S. Navy	450	8	Gas	Gubik Field—Fairbanks, Alaska	$20 million	Planned
Westcoast Transmission Company, Ltd.	270	8-26	Gas	Various locations in Peace River region	.....	Planned
Wilcox Trend Gathering System, Inc.	16	16	Gas	Gathering lines to Provident City, Texas	$2.9 million	Before FPC
Winnipeg and Central Gas Co.	450	4-8	LPG	Tioga, N.D.—Winnipeg, Canada	$20 million	Planned



STOP THOSE CORROSION LEAKS ON BURIED OIL, GAS AND WATER LINES WITH "CORECO" RECTIFYING SYSTEMS

Experienced "CORECO" engineers, specialists in design and installation of rectifier and galvanic anode cathodic protection systems, are ready to analyze and solve your corrosion problems.

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FOR COMPLETE CATHODIC PROTECTION

A Complete Design and Installation Service. Call, wire or write today to

CORROSION RECTIFYING COMPANY

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He's doing it Quickly and Correctly with a

LOWELL #50-A Reversible Ratchet Wrench

Here's why many major pipe line companies are asking for the new Lowell #50-A Wrench.

1—The reversible ratchet speeds installation of mechanical pipe line couplings.

2—Its special 8" handle assures correct torque on 5/8" bolts.

Other reversible ratchet wrenches available with handles up to 36" lengths.

Be sure of the right wrench for pipe line jobs . . . ask your industrial distributor for the #50-A or other Lowell Series 50 Wrenches.

LOWELL WRENCH CO.

WORCESTER 8, MASSACHUSETTS

This Link-Belt Speeder LS-98 with a 1-yd hoe totalled over 250 miles of cross country travel on a big pipelining spread. Its Independent Swing and Travel feature often saved as much as an hour a day.

In every size, Link-Belt Speeder shovel-cranes offer

more speed, stamina, power and work-time!

More speed — Speed-o-Matic, the true power-hydraulic control — smooth, positive response — perfect "feel" for speed with accuracy. Engineered to consider the human factor, greatly reduces operator fatigue.

More power — Get more line pull, digging power, lower fuel costs. Link-Belt Speeder design calls for precision-machining, anti-friction bearings and splined shafts at every point that transmits *rated* horsepower into *usable* horsepower.

More stamina — A Link-Belt Speeder withstands continuous heavy-duty, high-speed operation. For proof, compare similar sized rigs with and without counterweights. Link-Belt Speeders have more "live weight", more strength built into every component.

More work-time — A bigger percentage of shift is spent in actual "work-time." By minimizing operator fatigue, Speed-o-Matic boosts output up to 25%; also eliminates frequent on-the-job clutch adjustments and maintenance.

CHECK THESE BRIEF SPECIFICATIONS

Model	58 Series* Models	68 Series* Models	88 Series* Models	98 Series* Models	108 Series Models**	K-300 Series Models	K-608 Series Models
SHOVEL RATINGS (Cubic yards)	½	¾	¾	1	—	1½-1¾	3
DRAGLINE AND CLAMSHELL							
Standard Boom Length (ft.)	30	30	35	40	40	50	60
Rating (cu. yds.)	½	¾	¾	1¼	—	1½-2	3
LIFTING CRANE							
Standard Boom Length (ft.)	30	30	35	40	40	50	60
Min. Radius (ft.)	10	10	10	10	10	12	12
Safe Rating at Min. Radius (tons)	8.2-12.5	11.2-17.5	16-25	22-30	35	26.6-36.6	68.4-74.5□

*Series includes crawler, truck and wheel-mounted self-propelled model.
**Truck-mounted only.
□For comparative rating purposes.

The "super" on this job said, "We asked this rig to swing more pipe than any other rig had before. It came through with flying colors."

13,829-A

You're ahead on every job—

because Link-Belt Speeder is *years ahead* of the shovel-crane industry. Only Link-Belt Speeder offers you Speed-o-Matic's true power hydraulic control and so many other outstanding design and construction advantages. For facts on every machine in the ½ to 3-yard, 8 to 75-ton work range, contact your Link-Belt Speeder distributor. Link-Belt Speeder Corp., Cedar Rapids, Ia.

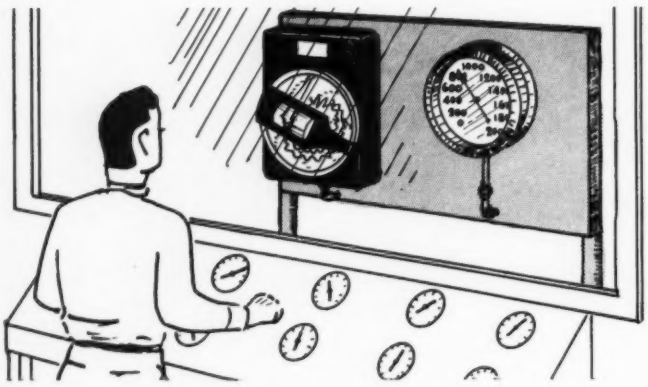
LINK-BELT SPEEDER

Factory-trained distributor sales and service specialists everywhere

How to do it

PIPE LINE HINTS

$10 is paid for each illustrated acceptable contribution. Mail to The Editor, PIPE LINE INDUSTRY, P. O. Box 2608, Houston 1, Texas

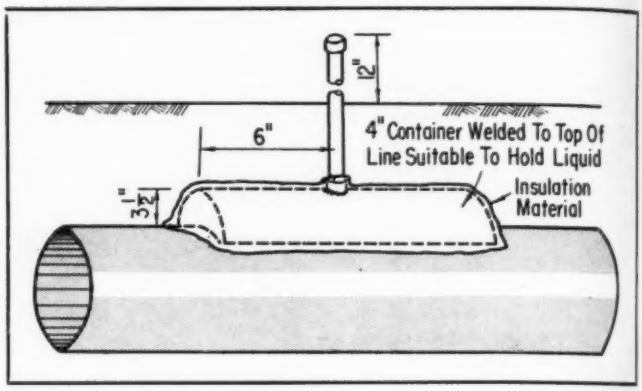


Magnifying Glass Facilitates Reading Recording Charts

A high-power reading glass fastened to the face of a recording chart saves one operator time and steps from the control room to the recorder. A large picture window is between the operator and the recording chart at the Midwestern pumping station. The pressure gage can be read easily; the fine lines on the recording chart are clearly seen by the operator from the control room.

The glass is mounted to a sheet aluminum bracket which bolts to the cabinet door as shown. The depth of the legs of this bracket depend upon the distance from the chart to the operator's position for proper magnification.

The glass is about 2¼-inches by 3½-inches and covers the full range of pressure from 0 to 1000 pounds. For less than $3 materials cost, the operator saves lots of steps.



Thermometer Well Proves Economical in Flow Tests

This thermometer well design shown gives one Panhandle operator highly accurate gas temperature readings at very low cost per installation. The device saved an estimated $1000 last year during two flow tests over a gas transmission system.

Each well consists of a portion of 4-inch pipe with the ends sealed as shown. The well is welded longitudinally to the top of the line. A riser is attached to the well by a coupling, allowing the thermometer to be inserted from above the ground. Ethylene glycol placed in the well to a three-inch level conducts the temperature of the gas by contact with the pipe.

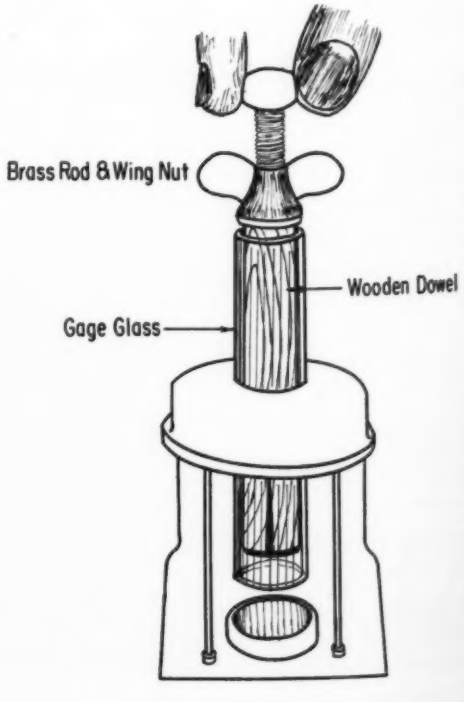
Asbestos insulation around the well helps maintain a constant temperature.

Tool Cuts Down Breakage In Gage Glass Removal

The device shown has cut down breakage by 90 percent during overhaul with tank level gage glasses and engine force feed lubricator sight glasses at one compressor station. Glasses often become sticky and difficult to remove without breakage. The device is a time-saver too.

The tool is made up of a wooden sleeve that encases a shorter internally threaded metal sleeve in one end. The lower end of the wooden sleeve has two slots cut into it at right angles. A threaded rod with a wing nut on one end and a cap on the other fits inside this sleeve. The diameter of the cap is larger than the internal diameter of the wooden sleeve; movement of the rod and cap upward in the sleeve causes the slotted outer sleeve to push outward and firmly grip whatever may be encasing it.

By inserting this tool in gage glasses and turning the wing nut "handle" until the tool's wooden shank binds on the glass, the glass can be removed easily with little danger of breakage.

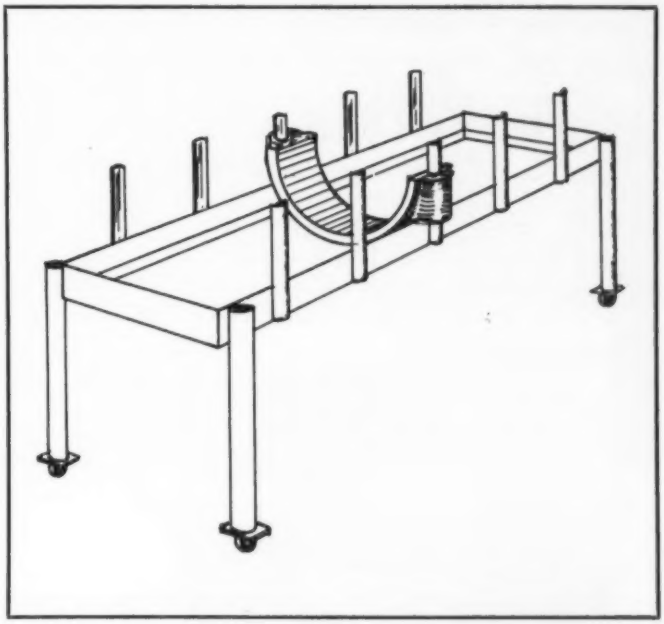


Side Boom Frame Speeds Light Stringing Jobs

A detachable welded pipe boom makes a flatbed truck ready for pipe stringing. This handy frame, designed for light work, consists of a 4-inch pipe frame which rests on the truck bed and a 6-inch boom welded to braces as shown. This boom assembly is chained to the truck bed pointing aft during road travel. When on location, it is turned 90 degrees and again secured with load binders for stringing work. It also is useful as an A-frame for lifting when pointed aft.

A pair of snatch blocks are then attached to the boom as shown, one hooked to the end of the boom and the other tied near the base. The hoisting cable is threaded through these blocks to the winch at the back of the cab.

Roller Stand Keeps Parts Handy During Overhaul

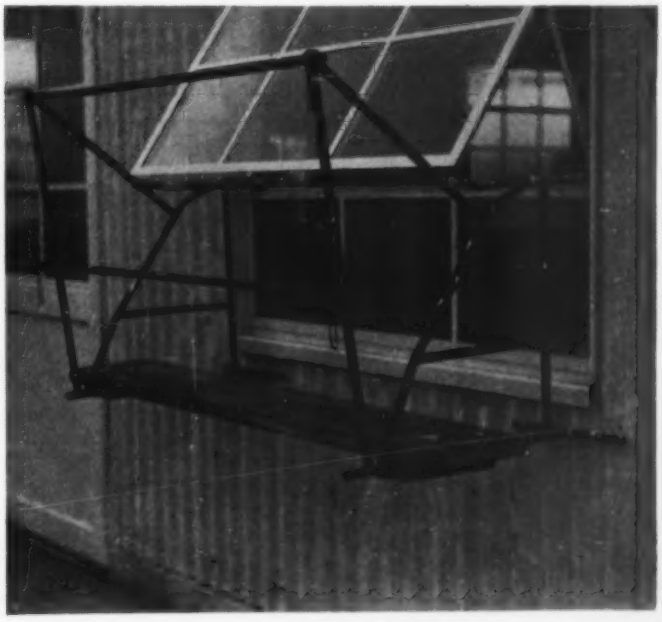


To keep parts such as connecting rod caps, shims, top bearing halves and nuts where you want them during overhaul periods, make this roller stand in the station shop.

Split sections of 1¼-inch pipe are welded to each side of an angle iron frame sized so that the pipe sections fit the holes of connecting rod caps. The pipe extends high enough for shims to lay in place. One cap is shown in position with places for five more available. The number of holders can be adapted for the particular overhaul job.

A small angle iron frame at the bottom holds a plywood shelf where upper bearing halves and nuts for the connecting rod bolts can be placed. Casters are fastened to the cart for mobility.

Adjustable Scaffold Makes Station Cleaning Easier

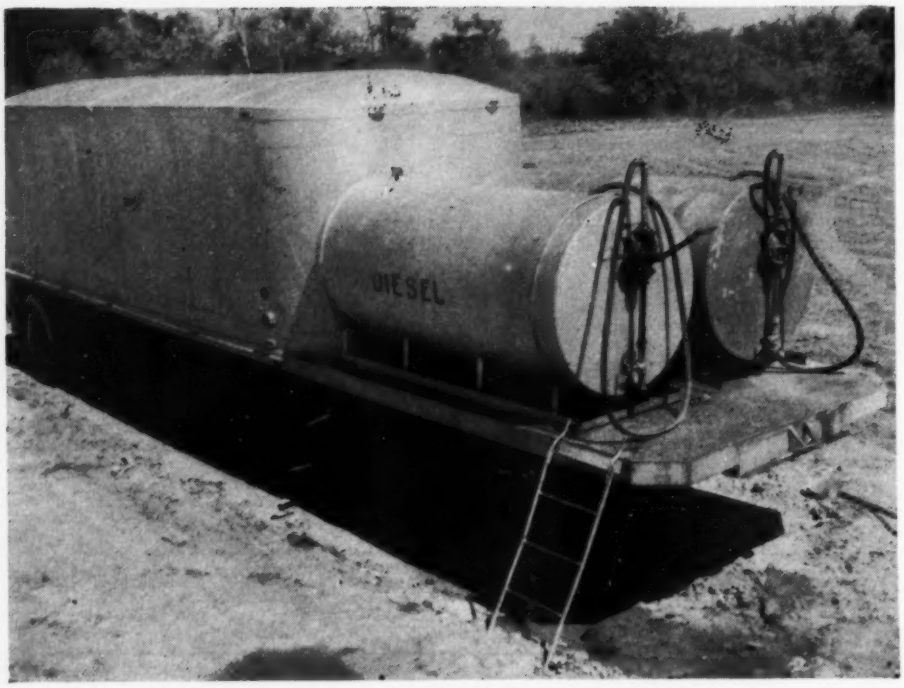


An adjustable scaffold fabricated at a South Texas compressor station speeds outside work safely. The scaffold can be adapted for windows or openings of various widths.

The scaffold is made up of welded scrap pipe, two pipe rails across the back, and a wooden plank assembly used for a footwalk. The side assemblies have two rings attached on the back side into which the rails fit. Lock pins fastened by chain to these rings are inserted in holes drilled into the rails to adjust the width of the scaffold.

Side rails have a short cross member welded to the bottom to bear against the window frame and a cross member at the top to hook inside the window frame as shown. Two wedges are nailed to the bottom of one end of the wooden footwalk to keep it from slipping.

This scaffold is easily disassembled by removing the lock pins and pulling the parts inside the window. It can be re-assembled quickly at the next window.



Long Trailer Carries Fuel and Equipment

One pipe line contractor found a profitable use for an old and little-used truck trailer. By adding a new front end, he adapted it for hauling fuel and equipment.

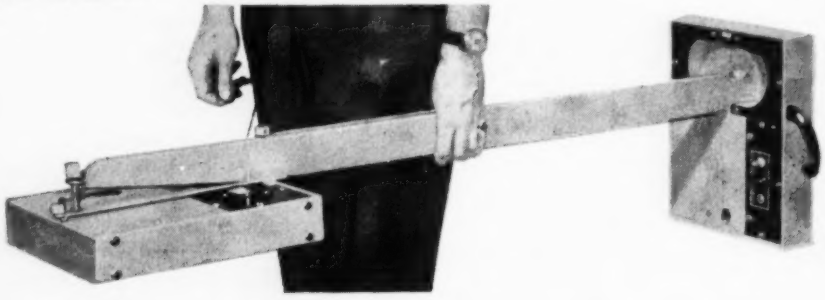
The trailer extension is a steel platform large enough to accommodate two fuel tanks installed side by side. The fuel tanks are fastened to support brackets which bolt directly to the platform. The hitch mechanism and parking support wheels are relocated forward under the platform. The covered part of the trailer serves to house tools and light equipment.

Although this adaptation raises the load and length limits of the trailer above those usually allowed on state and U. S. highways, the acquisition of an additional permit makes the trailer's use legal and very practical.

The WILKINSON LINE LOCATOR

SEES WHERE YOU CAN'T

It will instantly locate all subsurface pipes, cables and such, and determine their depth too. The etched circuitry, our latest innovation, assures better quality control and performance than the customary hand wiring method. You can avoid damaged structures and loss of time with the Wilkinson Line Locator.



WILKINSON PRODUCTS COMPANY

3987 Chevy Chase Drive, Pasadena 3, California. SYlvan 0-4314

Alphabetic Markers Aid In Reporting Repair Spots

One Midwestern pipe line company has devised a method of finding quickly repair locations along a pipe line. Metal letters 16 inches high mounted on pipe as shown do the job.

Designed for short lines, this plan divides the system into 26 or less sections, each given a letter of the alphabet. The linewalker reports leaks or other trouble as being located in the JK section, for example, a certain distance from a known landmark. The maintenance men then can go directly to the trouble spot without wasting time in hunting the location.

NOTICE: Specify **PELCO** Welding Saddles

No change except the corporate name. We still have the same ownership, same management, same address, same telephone, and use the same 45 years of experience to render the same service under the same trade name—"PELCO."

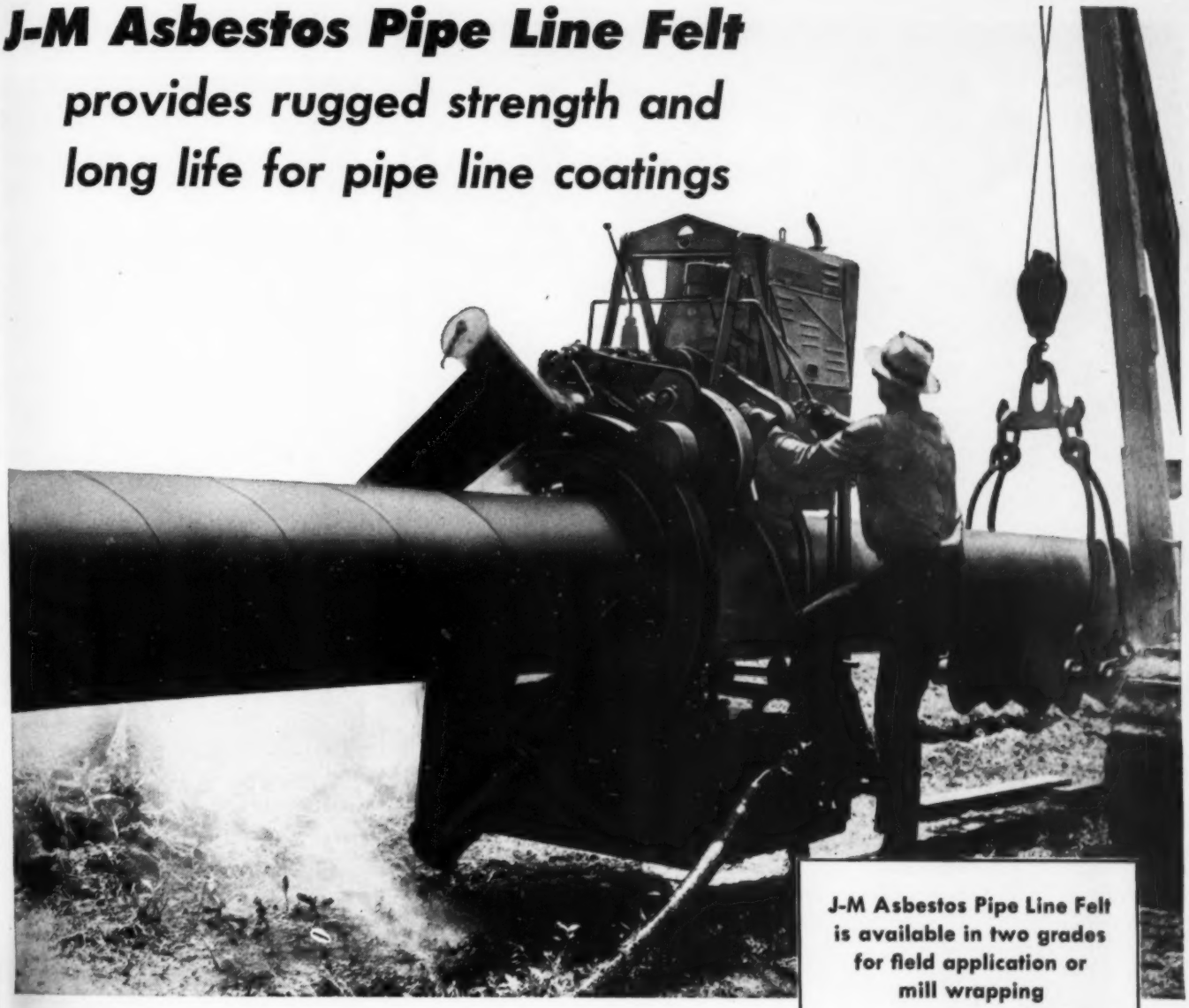
PELICAN SUPPLY CO. INC.

P. O. Drawer 1108 Shreveport (84), La.

SEE YOUR NEAREST SUPPLY HOUSE

J-M Asbestos Pipe Line Felt

provides rugged strength and long life for pipe line coatings



Permits high-speed wrapping and effective protection for enamels

Johns-Manville Asbestos Felt gives pipe line coatings the rugged strength that is needed to guard the enamel from years of soil action. It forms a *stable* coating to reduce the hazards of pipe line corrosion leaks and provides a sound foundation when cathodic protection is used. Inorganic asbestos felt is the only wrapper that has survived more than half a century of actual service conditions in all types of soils.

J-M Asbestos Pipe Line Felt acts as a continuous sheath over the enamel... guarding the coating from the effect of the shifting grip of the soil as it expands and contracts due to alternate wetting and drying. It resists the destructive action of bacteria, fungi and soil chemicals, thus assuring long life to pipe line coatings.

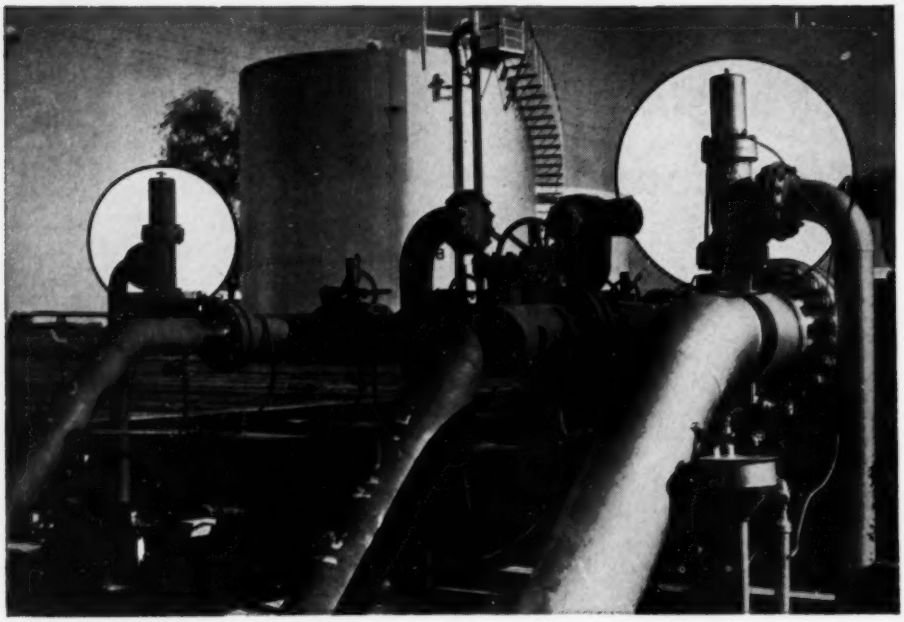
J-M Asbestos Pipe Line Felt is available in two grades for field application or mill wrapping

Transhield Asbestos Pipe Line Felt—for average soil conditions.

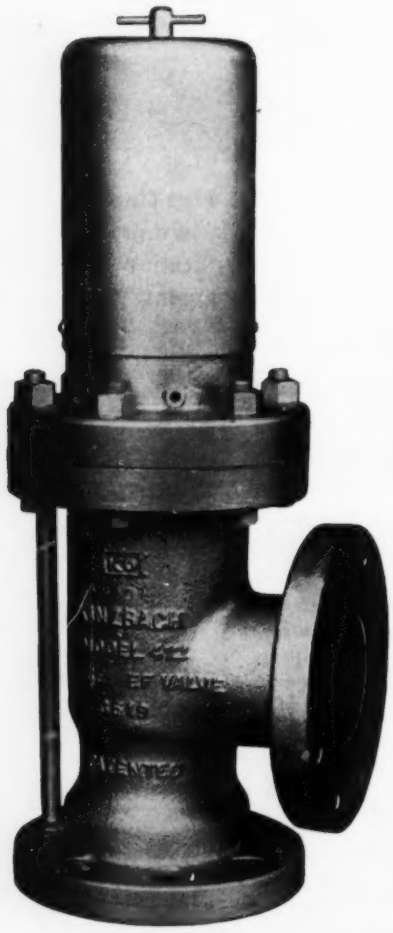
#15 Asbestos Pipe Line Felt—heavy-duty material for severe soil conditions where a heavier material is desired.

For further information about Johns-Manville Products for Pipe Line Protection, write to Johns-Manville, Box 60, New York 16, N. Y., in Canada, Port Credit, Ontario.

Johns-Manville ASBESTOS FELT FOR PIPE LINE PROTECTION



Positive Protection Against Pressure Surges



KINZBACH
MODEL 412
RELIEF VALVE
for Pipelines and Refineries

When a pressure overload in the line is reached, the Kinzbach Model 412 Relief Valve opens instantly to full capacity. This valve provides automatic resetting at a pre-determined pressure drop, positive seating and facilities for functional testing.

The Model 412 uses line pressure for opening and closing. The opening pressure is preset by application of a dead weight load. Opening and closing action is positive and reliable. The pre-set pressure never changes.

Kinzbach Model 412 Relief Valves are available in 2", 3", 4", 6" and 8" sizes for working pressures up to 1000 p.s.i. Write for Bulletin RV412 for full technical data.

KINZBACH TOOL CO INC

KINZBACH TOOL COMPANY, INC.

P. O. Box 277 Houston, Texas

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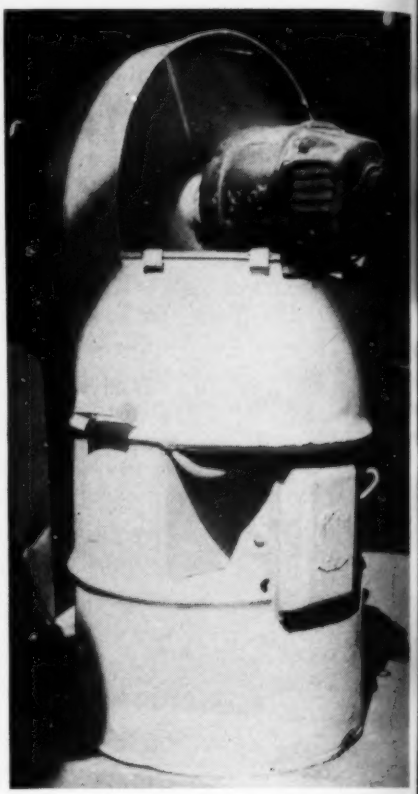


Convert Oil Drum Into Stand for Fan

Where additional ventilation may be needed around a station or shop, an old oil drum can be converted into a fan stand as shown.

A notch is cut in one side of the top, and the top section of another drum is cut out to form a guard for the fan. The fan motor is fastened to a plate which fits inside the top of the drum.

Handles welded to the side of the drum make it easily portable. It may be moved to exhaust heat from a hot spot around an engine or turned toward a work area.

The switch for the fan is installed in a well cut between the drums' two middle chimes.

Make Gas Odorizer From Pipe Fittings

Here is a simple method of odorizing gas to protect small stations and tool houses. This setup utilizes common pipe connections generally found in the warehouse.

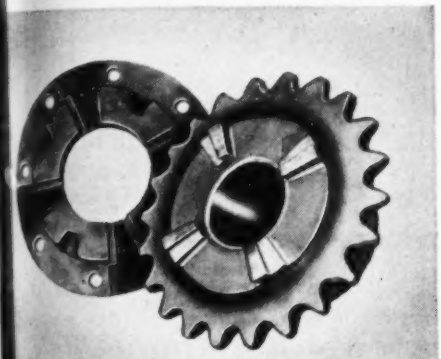
A 1-inch tee, bushing to ½-inch, ½-inch nipple, ½ to 1-inch reducing collar, and a 1-inch nipple approximately 12 inches long are made up as shown.

The 12-inch nipple is welded shut

20 to 84%, power boosted,

International-Superior Pipe-Boom Tractors

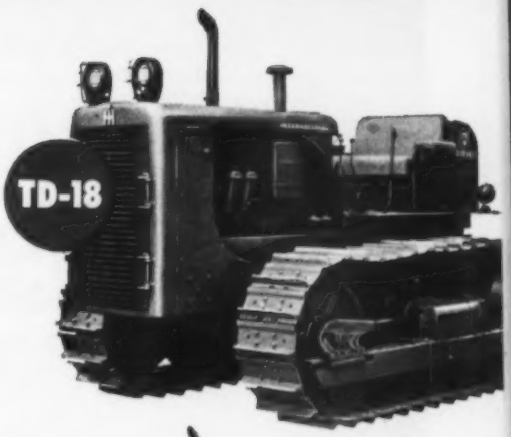
w non-slip, jaw-type drum clutches, with
wer both up and down, provide positive load
trol. Smooth operation assured by full-circle
ow-out collars.



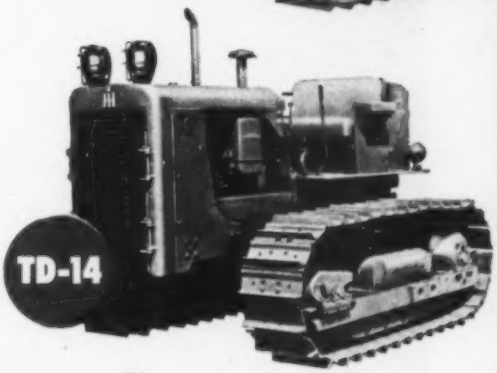
new models

**w self-energizing, wrap-around, heavy-
y drum brakes** for greater operating ease.
ed practically no adjustment, no mainte-
ce. Fingertip control reduces operator fatigue.

NEW TD-18 (Series 182) delivers 124 net engine, 103 drawbar hp. Gives you excellent balance, exceptional all-around visibility, operating ease never before available. New heat-defying cerametallic engine clutch facings reduce lever-pull 50%, cut maintenance 75%.

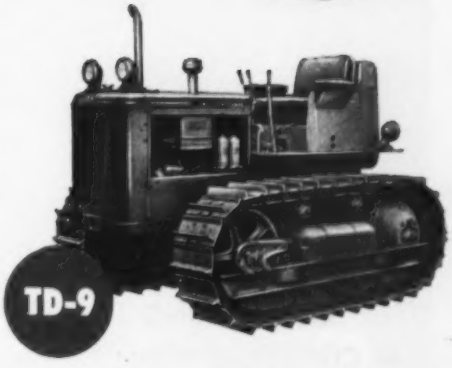


NEW TD-14 (Series 142) boosted to 95 net engine, 78.5 drawbar hp. Features "new-look" engineering, job-speeding visibility, new boom and blade carrying and operating strength. As on all sizes of International tractors, all-weather electric starting is standard.



NEW TD-9 (Series 91) now delivers 66 net, 54.5 drawbar hp—up 32%! Now in a new heavy-duty job range. Increased power backed by new, stronger power train and track frame, new operating and servicing ease.

Measure . . . compare . . . prove to yourself . . . these 1956 bonus-powered International-Superior pipe-boom tractors beat anything else on tracks! Try this "Big Inch" power for work-ability . . . operator preference . . . profit-potential! Ask your International Industrial Power Distributor for a demonstration! Call him today!



International-Superior

For details on any machine shown, see your International Construction Equipment Distributor, or write International Harvester Company, 180 N. Michigan Ave., Chicago 1, Illinois: Manufacturers of Pipe-Booms, Crawler and Wheel Tractors . . . Self-Propelled Scrapers and Bottom-Dumps . . . Tractor and Rubber-Tired Loaders . . . Diesel and Carbureted Engines . . . Motor Trucks.

or capped on one end. The reducer, ½-inch nipple and bushing are screwed on. The device is filled to a point in the small nipple with malodorant, and a piece of sash cord is dropped into this container so that it protrudes about three inches. The tee is then placed at a convenient place in the gas line on the downstream side of the low pressure regulator and the assembled odorizer is screwed into it.

The wick will feed the malodorant into the gas stream and the device need only be checked for refilling once a year.

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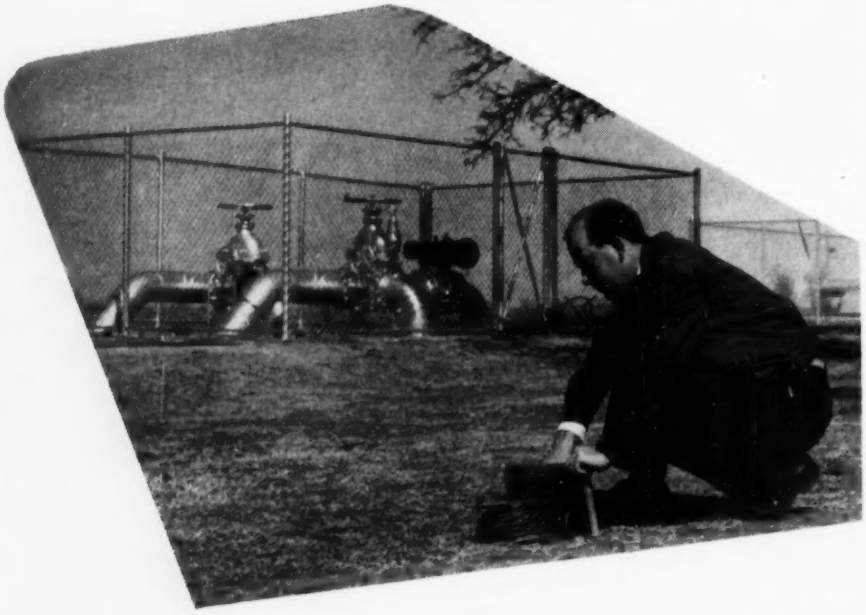

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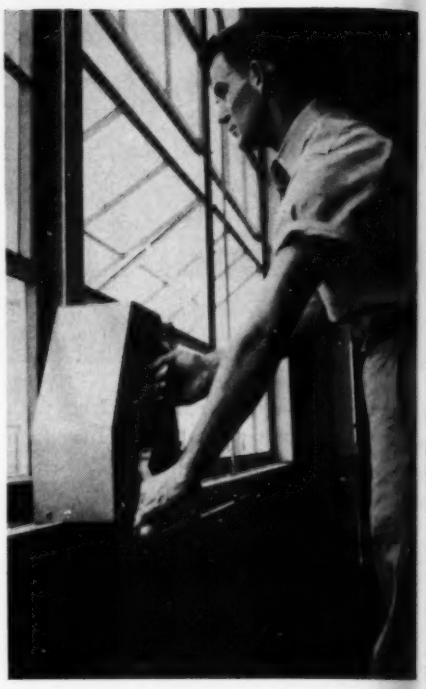

Station Valve Controls Made Readily Accessible

A time-saving idea in compressor station design is to place the pneumatic pilot control mechanism inside the building instead of outside on the catwalk. The arrangement shown recently was installed in a new station.

The three handles control valves operating station suction, discharge and bypass. The operator can observe valve operations while controlling them from inside the building.

The half-inch steel tubing controls the multiple port valve to the valve operators. Closure of discharge valve stops fuel gas supply to the engine and shuts down compressor. All the piping is under 250 pounds pressure.

Simple Valve Platform Makes Operation Easy

Valve platforms are often helpful to men operating sectionalizing valves on pipe lines.

One Oklahoma company equips above-ground valve settings with the simple platform shown. Made from readily available material in a station shop, the platform puts the person who operates the valve within easy reach of the valve wheel.

To fabricate the platform, a frame and handrail are first made of lightweight angle iron. The floor is then cut from non-skid steel floor plate. U-bolt clamps secure the platform

For more data on advertised products, use Readers' Service Cards, last page.

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LESS EXPENSIVE THAN A FIELD-WELDED VENT

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Simply slip the vent collar down over pipe and tighten two set screws.

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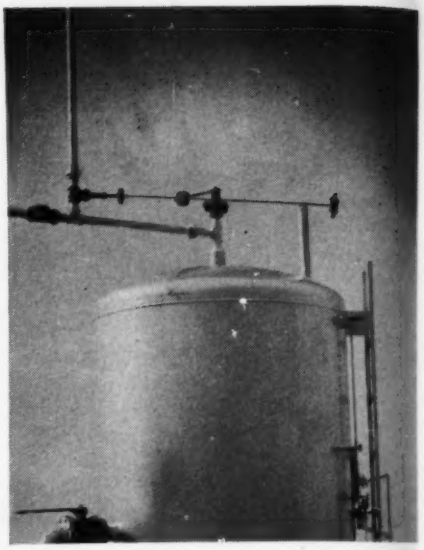
frame to the main pipe near the side of the valve bonnet as shown. The result is a safer platform that makes work easier.

Work Hard-to-Reach Valve With Handle Extension

A simple handle extension that can greatly reduce the risk in operating "just-out-of-reach" tank valves is pictured. A steel rod was cut long enough to extend to the nearest ladder and was fastened to the small handwheel of the valve.



A support consisting of a tubular stand and a guide sleeve for the extension rod was welded to the top of the tank. Another handwheel brazed to the end of the extension completes the installation and permits the operator to work a valve three feet from his ladder.

BRADEN WINCHES ARE:

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★ **STRONG:** Engineered for ruggedness. All moving parts, such as worm gears, made of steel and bronze alloy.

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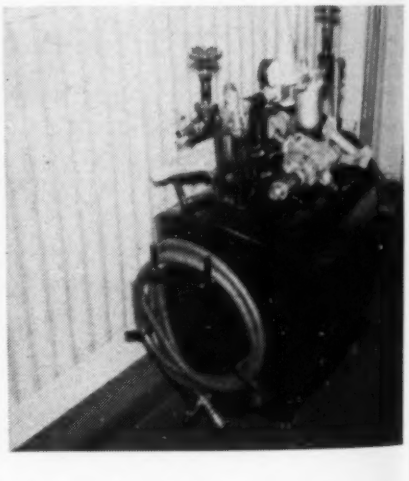

Portable Volume Tank Doubles as Tool Rack

Air tools and accessories may be attached to a portable volume tank as shown to make up a practical and compact unit. The tank is made from 22-inch pipe 30 inches long with a ¼-inch steel plate welded on the bottom. Casters are bolted to the plate for ease in transporting from engine to engine about the station.

The pressure regulator, filter, gage and oiler are mounted on top with valves and couplings for air hose. Brackets are spotwelded to the tank for attaching an air drill, impact wrench, handles, keys, chucks and lead hose on both ends.

Pipe Line Men

IN THE NEWS

Richard J. Titus

Richard J. Titus, a graduate engineer from Georgia Institute of Technology, has joined the staff of PIPE LINE INDUSTRY as associate editor. Besides his engineering degree, Titus received a B.A. in journalism from the University of Houston in 1950 and gained experience in that field editing two publications in Houston and writing for the *Beaumont Enterprise*. He worked for aircraft manufacturers in Ohio and Missouri and most recently was a design engineer for Anderson, Greenwood & Company in Houston. He served in the Navy for three years during World War II.

•

Lamont J. Brundige, Sacramento division manager of **Pacific Gas and Electric Company,** has been named manager of the San Jose division. **Richard L. Hayden,** San Francisco, manager of customer and community services, succeeds Brundige. Brundige, who succeeds the late William R. Bowler as manager of the San Jose division, has been manager of the Sacramento division since 1946. Hayden, who was a vice president and director of the Coast Counties Gas and Electric Company at the time of its merger into Pacific Gas and Electric in 1954, has been in the utilities business since 1931.

Southwest Gas Producing Company, Inc. has appointed **James H. Anderson** manager of gas project development. He will be in charge of the new office which Southwest Gas has opened in Shreveport. Anderson formerly was employed by Mississippi River Fuel Corporation of St. Louis as manager of gas supply. In his new position Anderson will be concerned with various phases of gas projects, particularly with those related to development of intra-state gas markets and sources of supply.

•

Colorado Interstate Gas Company has announced the re-election of all its officers. Re-elected at the recent meeting were **W. E. Mueller,** Colorado Springs, president; **J. P. Roetzel, S. Cassell Barrett** and **G. F. Brunston,** all of Colorado Springs, **J. P. Moroney,** Denver, **William A. Dougherty,** New York, and **Albert R. Jones,** Kansas City, Mo., vice presidents. **James Lawrence White,** New York, was renamed as general counsel; **L. M. Poe,** re-appointed secretary; **W. B. Kice,** treasurer; and **L. M. Stone,** controller. Poe, Kice and Stone are from Colorado Springs.

•

Southern Pacific Pipe Lines, Inc., has announced the appointment of **C. B. Miller** as assistant to the general manager with headquarters in Los Angeles. Other appointments include **J. B. Brock,** chief operator-deliveryman in El Paso; **J. R. Davis,** field superintendent of the Eastern district with headquarters in El Paso; and **R. R. McDaniel,** field superintendent, Northern district with headquarters in San Francisco.

•

Albert K. Mitchell, a rancher of Albert, N. M., has been elected to the board of directors of **Colorado Interstate Gas Company.** Other members of Colorado Interstate's board are **W. E. Mueller,** president; **William A. Dougherty,** New York; **Albert R. Jones,** Kansas City, Mo.; **John Evans,** Denver; **Robert W. Hendee,** Colorado Springs; **Joseph H. King,** New York; **Mark J. Millard,** New York; and **F. T. Parks,** Denver.

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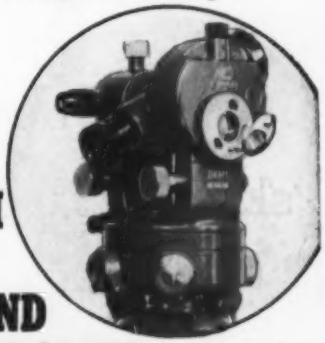

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L. E. Minor

Hal A. Lindsay

Brown & Root, Inc. and its affiliated company, **Brown & Root Marine Operators, Inc.** have announced the election of two vice presidents. **Louis Edward Minor,** manager of the Pipe Line department, was named a vice president of Brown & Root, Inc. and **Hal A. Lindsay** was named vice president of Brown & Root Marine Operators, Inc.

Minor was president of Oil Field Service Company in Williston, N. D., and also Well Perforators, Inc. before he joined Brown & Root in 1953. He began his oil industry career with Carter Oil Company, where he rose from roustabout to assistant field superintendent. He was later field and drilling superintendent for Banducci Oil Company in Bakersfield, Calif.

Lindsay joined Brown & Root in 1929 in sales and promotion work. He was moved to Houston in 1943 and went into the company's marine operations in 1947. Lindsay was instrumental in contracting for the first steel offshore platform built by Brown & Root in the early phases of offshore drilling and this platform was set in the Eugene Island area for Kerr-McGee Oil Industries, Inc. Since then he has been associated with offshore platform work of the company.

•

William H. Sloan, assistant to the manager of the company's Pipe Line Transportation division of **Cities Service Oil Company (Del.),** has been appointed superintendent of natural gas liquids in Cities Service's Supply and Distribution division. Sloan joined Cities Service Oil Company in 1947 as special projects engineer in the Natural Gasoline division. He was advanced to supervisor of the division's new development section and transferred to the Pipe Line Transportation division in 1954.

•

M. E. Foster has resigned as president of **Phillips Pipe Line Company** and will retire June 30. Foster has been in the oil business since 1919 and with Phillips for more than 32 years. He will open an office in Bartlesville, Okla., as a consultant in the supply and transportation field. **D. M. McBride** was elected president of Phillips Pipe Line Company and **Myron O. Johnson** elected vice president and general manager. All other officers and directors were re-elected.

•

Volney H. Kyle, Jr., vice president and manager of operations at **Michigan-Wisconsin Pipe Line Company,** has resigned his position to engage in consulting engineering activities at Groose Pointe, Mich.

•

C. A. Callahan has been appointed vice president in charge of company operations in the East for **Majestic Contractors Limited.** He will have headquarters in Toronto. Callahan started in the pipe line construction industry in 1946 with William Brothers. He served as project engineer and superintendent of some of the major pipe lines and pumping stations in the U. S., South America and in the Middle East. Callahan moved to Canada with his firm in 1951.

a reputation of integrity
skill and dependability...

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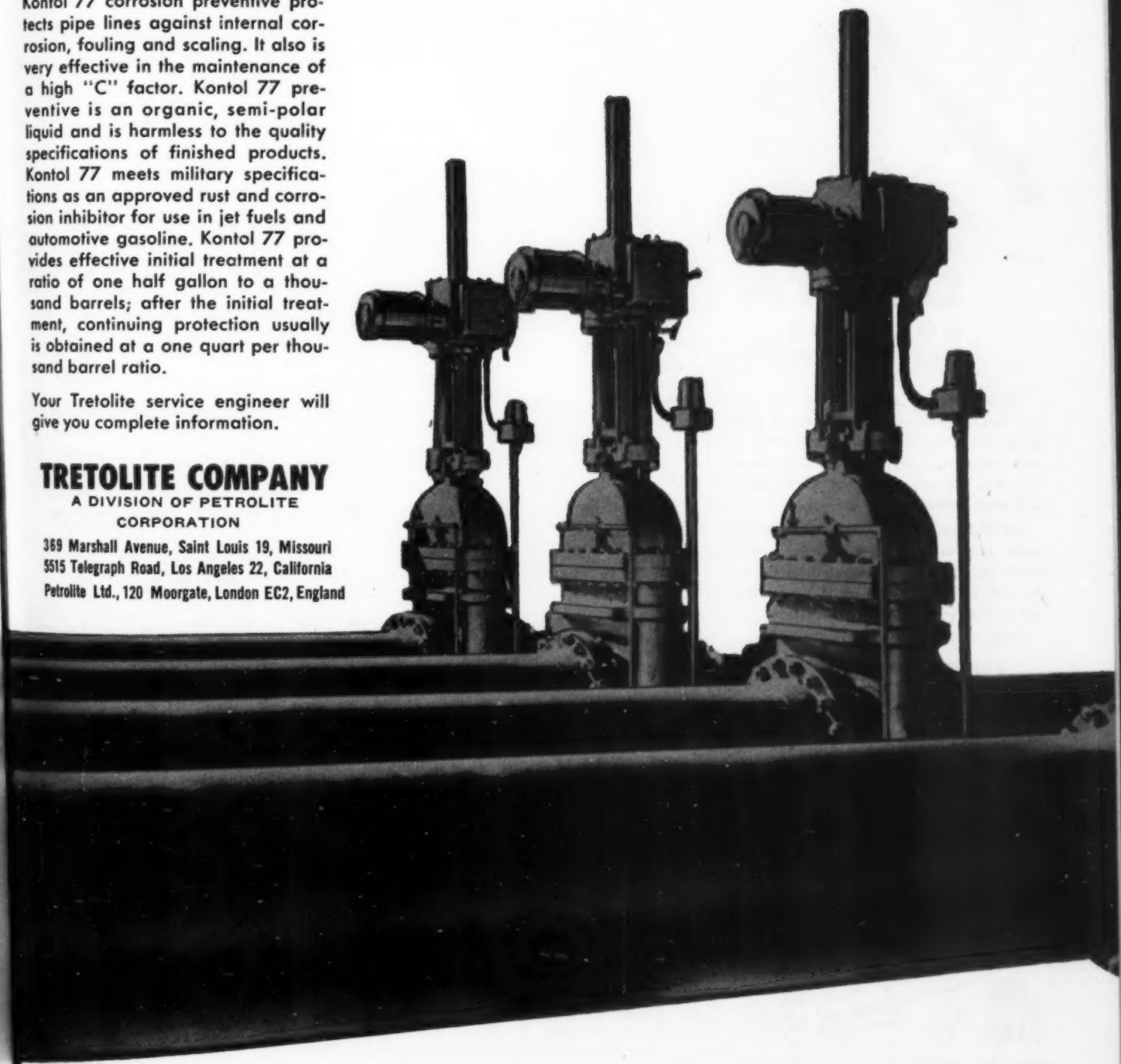

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LUBRICANTS FITTINGS GUNS LUBRICATORS

A. L. Roberts, general superintendent of operations for **Texas Gas Transmission Corporation,** has been elected a vice president. He will continue as general superintendent and will assist L. E. Ingham, vice president, in directing operations and maintenance of the 3500 mile Texas Gas pipe line system. Roberts has been general superintendent since 1949. He joined Missouri-Kansas Pipeline Company in 1930 as district superintendent and later served in the same capacity with Kentucky Natural Gas Corporation.

A. L. Roberts

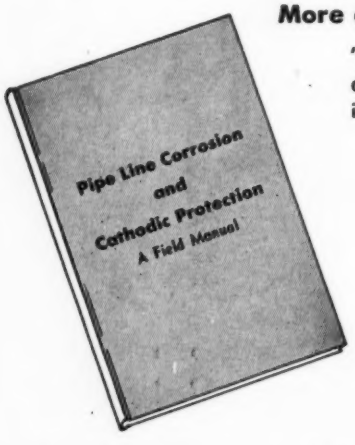
•

R. A. Puryear, Jr., of Alabama Gas Corporation, Birmingham, was elected president of the **Southern Gas Association** at its annual convention in Dallas. Other officers are first vice president, **Curtis M. Smith,** vice president of Tennessee Gas Transmission Company, Houston; second vice president, **Carl E. Cloud,** president of MidSouth Gas Company, Little Rock, Ark.; chairman of the advisory council, **A. H. Weyland,** consultant, Arkansas Louisiana Gas Company, Shreveport; vice chairman of advisory council, **James A. Davis,** president of Empire Southern Gas Company, Fort Worth; secretary, **Dale E. Frieden,** president of Zenith Gas System, Alva, Okla.; assistant secretary, **Kyle H. Turner,** supervisor of General Accounting department of Atlanta Gas Light Company, Atlanta, Ga.; and treasurer, **Willard G. Wiegel,** treasurer and director of personnel, Lone Star Gas Company, Dallas.

Directors of Southern Gas Association include **W. R. McLaughlin,** Southwestern regional manager, Rockwell Manufacturing Company, Dallas; **E. Clyde McGraw,** executive vice president, Transcontinental Gas Pipe Line Corporation, Houston; **P. F. Falk,** president of West Tennessee Gas Company, Jackson, Tenn.; **Minor C. Sumners,** president of Mississippi Valley Gas Company, Jackson, Miss.; **Earl J. Newlin,** president of State Fuel Supply Company, Oklahoma City; and **John F. Forsyth,** assistant to the president of Mobile Gas Service Corporation, Mobile, Ala.

More comments on this new Handbook:

"... a most practical on-the-job manual for men concerned with pipe line corrosion. We are ordering copies for each of our district engineers."



Pipe Line Corrosion and Cathodic Protection

By MARSHALL E. PARKER

This Handbook, written by Marshall E. Parker, consultant, is designed as a practical field manual. It is a 108-page pocket-size volume printed first as a popular series in WORLD OIL. The Handbook is illustrated with many charts and drawings and is completely indexed by subjects.

It presents comprehensive data on Soil Resistivity Surveys, Potential Surveys, Line Currents, Current Requirements, Rectifier Systems, Ground Bed Design, Magnesium Anodes, Stray Current Electrolysis, Interference in Protective Systems, Operations and Maintenance, and Coating Protection and Testing.

An appendix has been added of technical data on Underground Corrosion, Basic Principles of Cathodic Protection, Properties of Metals and Attenuation Equations. Order copies of this practical Field Manual now for each of your field men. Price $3.

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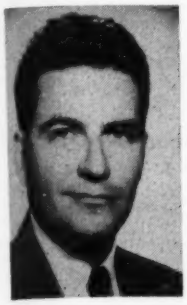
David J. Kerr has been appointed director of business development for **Southern Union Gas Company** with headquarters in Dallas. Kerr will be responsible for the coordination of advertising, merchandising and general promotional activities in the natural gas utility's operating territory.



David J. Kerr

Before joining Southern Union Kerr was serving as assistant to the executive director of the Natural Gas and Oil Resources Committee in New York. Previously he had been associated with the Gulf Interstate Gas Company and H. C. Price Co., as public relations director and advertising manager.

•

Southern Counties Gas Company has announced the election of **James A. Millen** to the board of directors. Millen, a vice president of the gas company, heads its transmission and supply system, including the California portion of the Texas-California "Biggest Inch" pipe line. He also represents the company in gas purchase and other supply matters. Millen has been with Southern Counties since 1947, when he was named to head the newly-formed Texas-California pipe line division. He was promoted to manager of transmission and supply in 1951.

•

Howard L. Cline, Houston, has been named superintendent of compressor stations for **Transcontinental Gas Pipe Line Corporation.** Cline will supervise the staffs of the company's 21 compressor stations between Refugio, Texas, and Philadelphia, Penn. Formerly assistant superintendent, Cline succeeds **F. B. Haverfield,** who recently was named Transco's general superintendent. Cline had been assistant superintendent of the Compressor Stations department for Cities Services Gas Company before joining Transco in 1951.

•

I. H. Hughes has been named a vice president of **Sunray Mid-Continent Company.** He will serve as assistant to the president, **W. C. Whaley,** and will continue to serve as secretary to the company's salary policy

QUALITY CONTROLLED in every step of manufacture . . .

LONE STAR
API LINE PIPE

From mining of raw materials through the finishing operations in Lone Star's ultra modern pipe mills . . Lone Star line pipe quality is controlled every step of the way.

Lone Star Steel is a completely integrated operation . . primarily dedicated to serving the teeming Mid-Continent area. Lone Star, however, furnishes hundreds of miles of line pipe for distant projects such as the great Pacific Northwest pipe line. Lone Star pipe bends readily, wall thickness is uniform, and long lengths and weldability speed up construction.

Neighbor, wherever you are, specify Lone Star and we both get a good deal.

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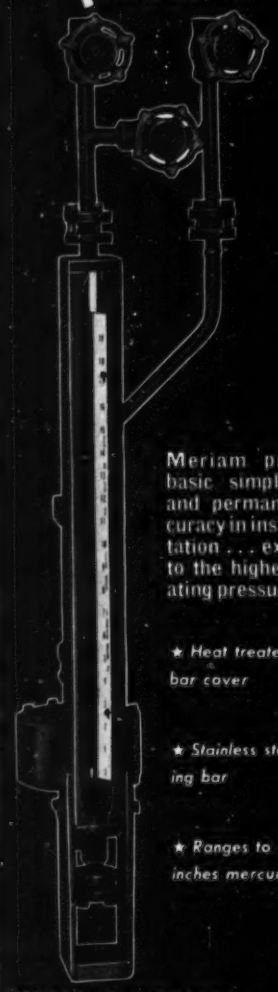
At pressures up to 2000 psi, this Meriam Manometer provides critically accurate flow or differential pressure measurement. Constructed of solid bar stock steel, all parts are precision fitted, hand lapped. Each unit is cold hydraulic tested to 5000 psi.



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Meriam Manometer Instrumentation

. . . for pressures, vacuums, flows, liquid levels.

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committee. Hughes joined the company in 1954 as assistant to the vice president of production for Mid-Continent Petroleum Corporation. Upon the merger of that company with Sunray in 1955, Hughes retained this position with the new Sunray Mid-Continent Oil Company until he was named to handle the company's salary policy and the new job training program.

WHO'S MEETING WHERE

Eleventh Annual Short Course in Gas Technology, Texas College of Arts and Sciences, Kingsville, Texas, May 30-June 1.

American Right-of-Way Association, Shamrock Hilton Hotel, Houston, June 14-15.

American Society of Mechanical Engineers, Applied Mechanics Conference, University of Illinois, Urbana, June 14-16.

American Society of Mechanical Engineers, Semiannual Meeting, Statler Hotel, Cleveland, June 17-21.

Canadian Gas Association, Manoir Richelieu, Murray Bay, Quebec, June 24-25.

Michigan Gas Association, Grand Hotel, Mackinac Island, Mich., June 24-27.

Rocky Mountain Oil and Gas Association, Midyear Meeting, Utah Hotel, Salt Lake City, June 28-30.

Independent Natural Gas Association of America, St. Anthony Hotel, San Antonio, Sept. 9-12.

Pacific Coast Gas Association, Annual Meeting, Coronado, Calif., Sept. 11-13.

Mid-Continent Oil & Gas Assoc., Louisiana-Arkansas Division, Annual Membership Meeting, Roosevelt Hotel, New Orleans, Sept. 20-21.

American Society of Mechanical Engineers, Petroleum Mechanical Engineering Conference, Statler-Hilton, Dallas, Sept. 23-26.

API Executive Committee of the Board of Directors, Greenbrier Hotel, White Sulphur Springs, W. Va., Sept. 26.

International Gas Union, Sixth Annual Conference, Hotel New Yorker, New York City, Sept. 25-30.

Texas Mid-Continent Oil & Gas Association, Rice Hotel, Houston, Oct. 2-3.

National Association of Corrosion Engineers, South Central Region, Beaumont, Texas, Oct. 2-4.

Oil Progress Week, Oct. 14-20.

AGA Annual Meeting, Atlantic City, N. J., Oct. 15-17.

American Institute of Mining, Metallurgical and Petroleum Engineers, Petroleum Branch, Biltmore Hotel, Los Angeles, Oct. 15-17.

American Society of Civil Engineers, Annual Convention, William Penn Hotel, Pittsburgh, Oct. 15-19.

Rocky Mountain Oil & Gas Association, Annual Convention, Cosmopolitan Hotel, Denver, Oct. 22-24.

American Society of Safety Engineers, Annual Meeting, Conrad Hilton Hotel, Chicago, Oct. 23.

American Petroleum Institute, Annual Convention, Conrad Hilton Hotel, Chicago, Nov. 12-15.

American Society of Mechanical Engineers, Statler Hotel, New York, Nov. 25-30.

Pipe Line Contractors Association, Ninth Annual Convention, Boca Raton Hotel and Club, Boca Raton, Fla., Jan. 14-16, 1957.

Petroleum Equipment Suppliers Association, Palm Springs, Calif., April 6-11, 1957.

See Composite and Refinery Catalogs, or Write for Specifications Folder

FLEET-LINE

PIPE SADDLES AND REDUCERS

Nozzle sizes from ¼" to 24"

ASTM A234

Also for pressure vessel heads

Special sizes and lengths. Schedules 10 to 160 Stainless Steel, and other Alloys.

Nominal pipe sizes 1" to 30"

ASA B16.9
ASTM A234

Immediate Delivery

STEEL FORGINGS, Inc.

P. O. Box 276K • Shreveport, La.

Foot of Fannin Street

NEW! Write for Bulletin.

Patented

PIPELINE VENTS AND MARKERS

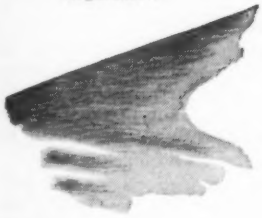
FLEET-LINE CO.

P. O. BOX 276K

SHREVEPORT, LOUISIANA

When Line Pipe Wears A STRAIT-JACKET

Open section of Hydropress is shown only to illustrate operation. Length of pipe is completely encased during expansion.



THE "Strait Jacket" is an important step in the Youngstown process of producing high strength line pipe to API-5LX specifications. This "Strait Jacket" is actually a hydraulic expansion unit in which the pipe is expanded within a set of enclosed dies. In this operation the ends are sealed, water is forced into the pipe and pressure is increased to expand it evenly against the smooth steel walls of the expander.

This process proof tests and cold works the pipe simultaneously. As a result Youngstown Electric Weld Line Pipe with uniformly high strength, with uniform weld quality, with uniform straightness, with uniform wall thickness and with uniform diameter is ready for you.

* * * * * *

Five reasons why Youngstown Electric Weld Line Pipe is your best buy: (1) It bends readily; (2) Wall thickness is uniform; (3) Line up characteristics are excellent; (4) Weldability is outstanding; (5) Long lengths save you time and trouble. The Youngstown Sheet and Tube Company, Youngstown 1, Ohio. Sales and service offices throughout the oil and gas producing areas.

Youngstown

ELECTRIC WELD LINE PIPE

QUALITY YOUNGSTOWN SERVICE

THE YOUNGSTOWN SHEET AND TUBE COMPANY *Manufacturers of Carbon, Alloy and Yoloy Steel*

General Offices Youngstown, Ohio District Sales Offices in Principal Cities.

SHEETS - STRIP - PLATES - STANDARD PIPE - LINE PIPE - OIL COUNTRY TUBULAR GOODS - CONDUIT AND EMT - MECHANICAL TUBING - COLD FINISHED BARS - HOT ROLLED BARS - WIRE - HOT ROLLED RODS - COKE TIN PLATE - ELECTROLYTIC TIN PLATE - BLACK PLATE - RAILROAD TRACK SPIKES - MINE ROOF BOLTS

For more data on advertised products, use Readers' Service Cards, last page.

What's Happening

AMONG SERVICE AND SUPPLY MEN

C. D. Cummins

E. D. Schively

Cummins Named District Manager For Worthington at Seattle

Charles D. Cummins has been appointed district manager of Worthington Corporation's Seattle office. Since 1949 Cummins has been assistant district manager. In his new capacity he succeeds E. D. Schively who has accepted a special assignment in Worthington's new Canadian operation.

The Seattle district office maintains a branch office at Portland, Ore., in charge of Norman E. Wolfe; and a sales operation at Spokane under Harley M. Yake.

Cummins graduated from Oregon State University in 1924 with a mechanical engineering degree. He joined Worthington in 1925 as a general line salesman at Seattle and in 1949 was appointed assistant district manager of that office.

Schively joined Worthington in 1916, after receiving his M.E. degree at the University of Washington. He served in various sales capacities until his appointment as district manager at Salt Lake City in 1920; and was made district manager at Seattle in 1924. He is completing forty years of service with Worthington interrupted only by fifteen months in the U. S. Army during World War I.

Nelson Stud Welding Appoints Distributor for Tulsa Area

Tulsa Welding Supply Company has been appointed distributor in the Tulsa area for the Nelson Stud Welding Division, Gregory Industries, Inc.

Stud welding guns, Nelwelder generators and portable battery sources will be available for purchase or rental through Tulsa Welding Supply, headed by James S. Cribbs. The most popular types of studs being used in the Tulsa area will be stocked for immediate delivery by the new distributor, along with parts and accessories for stud welding equipment. Tulsa Welding Supply also will handle Remington powder-actuated stud drivers, for which Nelson is a national distributor.

Mercoid Corporation Makes Executive Appointments

The Mercoid Corporation has announced the appointment of Willis E. Jones as sales manager. In his new position Jones will supervise general selling activities throughout the corporation.

Other appointments include Paul J. Provost, manager of Industrial Controls division; and G. R. Folds, Jr., who is recalled from the West Coast area to work with Provost in the new Industrial Controls division.

New Caterpillar Plant To Be Built at Aurora

Aurora, Ill., has been chosen as the site for a new plant of Caterpillar Tractor Co.

Four models of Caterpillar machines will be built in Aurora—the D2 and D4 crawler tractors, and the two corresponding sizes of Traxcavators, or tractor shovels.

Construction of the new plant will start in June, and production is scheduled to begin at the earliest practicable date.

With the completion of the Aurora plant, the space made available at Peoria by the removal of D2 and D4 facilities will be used to increase capacity to manufacture D6, D7, D8 and D9 tractors and all models of diesel engines.

In addition to the new plant, Harmon S. Eberhard, president, announced that additions will be built to the company's plants in Decatur and Joliet, Ill., and that additional machinery and equipment will be added to other plants under a four-year program designed to increase the Company's overall manufacturing capacity.

Miller Elected to Post With Cooper-Bessemer

E. L. Miller has been elected to the office of assistant general manager in The Cooper-Bessemer Corporation.

E. L. Miller

Acting upon the recommendation of Cooper-Bessemer's president, Lawrence F. Williams, Miller's new capacity places him directly under the president and general manager. In this capacity, Miller has responsibility for the over-all operations of the Company.

Miller joined the Engineering department of The Cooper-Bessemer Corporation in 1946, and was appointed assistant general manager in 1954.

Alco Products Appoints Ward Manager of Dunkirk Plant

Thomas L. Ward has been appointed manager of the ALCO Products, Inc. plant at Dunkirk, N. Y., succeeding W. L. Larson, who has resigned.

Ward's post as manager of manufacturing services will be filled by L. W. Eger, formerly production manager of thermal products at the Dunkirk plant since last year.

Ward, who has been with ALCO since 1937, joined the company in New York as assistant chief estimator and later worked in the New York office as assistant chief engineer. In 1953 he was transferred to Dunkirk as executive engineer and appointed marketing manager of the plant a year later. He became manager of manufacturing services last year.

Eger, who joined ALCO in 1937, has been assistant materials supervisor at Dunkirk and Auburn, N. Y., material control supervisor, manager of the Customer Services department, manager of the Sales Service department and production manager of thermal products.

B. J. Gross

O. Bliss Williams

Gross and Williams Receive W-K-M Manufacturing Posts

B. J. Gross was elected vice president for marketing and O. Bliss Williams appointed director of industrial and public relations of W-K-M Manufacturing Company.

Gross was president of the former Key Company of East St. Louis which became a part of W-K-M as a result of the recently announced consolidation. Williams was assistant to the president of the Key Company. Gross was with the Key Company for 23 years, starting in the Sales department, later becoming vice president in charge of sales. He was elected president of that company in 1948.

Williams was with the firm of Booz, Allen and Hamilton, management consultants, before joining the Key Company.

Insley Manufacturing to Build Facilities in California

Insley Manufacturing Corporation has announced that contract has been let for the construction of manufacturing facilities in Puente, Calif., for the manufacture of excavators, shovels, clam shells, log loading and other crane equipment.

The Maxi Corporation, subsidiary of Insley, will occupy the new plant also. Features of the new plant will include two crane-covered bays for production and assembly areas, a complete machine shop, parts and service departments, a paint room, traffic docks, test areas and exterior work areas, including space for field research and development.

James R. Elliott is president of Insley and Thomas J. Reedy, president of Maxi.

Whitfield Receives Promotion At Lone Star Steel Mills

William Whitfield, formerly assistant superintendent of Lone Star Steel's rolling mills, has been promoted to administrative assistant to J. M. Brashear, general superintendent of the E. B. Germany works. Succeeding Whitfield at the rolling mills is Jeremiah Sheehan, formerly shift foreman.

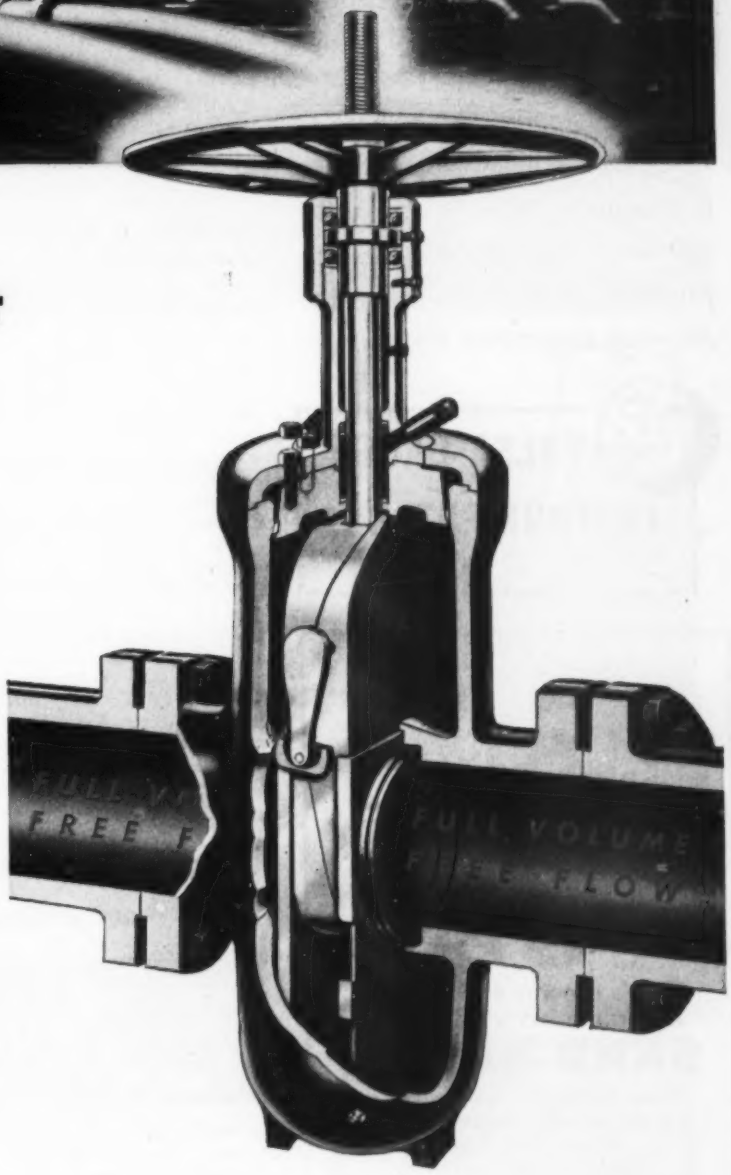
A native of England, Whitfield came to Lone Star Steel three years ago from Republic Steel at Warren, Ohio. He was shift foreman until his promotion to assistant superintendent in 1954. Whitfield brings 14 years of experience in steel mill work to his new job. Sheehan, formerly with Crucible Steel Company, has been with Lone Star for three years.

W-K-M Through-Conduit VALVES

Main lines with W-K-M Valves all the way are the "expressways" of pipeline transportation. The smooth bore through a W-K-M Valve is the same as the I.D. of the pipe and permits the same full volume, free flow as the pipe itself, and allows no more pressure drop or turbulence than an equivalent length of smooth wall pipe. Pump or compressor power is concentrated on transmission — not wasted overcoming obstructions. Scrapers may be run freely through the valves when cleaning the line.

Other advantages of W-K-M Pipeline Valves that contribute to their efficiency in service on the line are Leverlock Control of the parallel expanding gate; pressure seal bonnet that seals tighter as pressure increases; renewable seats; Superfinished stems, ball bearing operation for easier opening and closing under any conditions.

Write or ask your W-K-M Representative for our new pipeline catalog No. 300.



W-K-M MANUFACTURING COMPANY, INC.

A SUBSIDIARY OF acf INDUSTRIES INCORPORATED

PLANT: MISSOURI CITY, TEXAS • MAILING ADDRESS: P. O. BOX 2117, HOUSTON, TEXAS

MANUFACTURING

W-K-M THROUGH-CONDUIT GATE VALVES

acf LUBRICATED PLUG VALVES

KEY RETURN BENDS AND FITTINGS

For more data on advertised products, use Readers' Service Cards, last page.

OLD SLUSH POND GETTING YOUR GAUGES?

REPAIR THEM!

Throwing away worn gauges is expensive. Save ½ to ⅔ the cost of a new one with our dependable, quality repair service. All work guaranteed. Fast return.

TULSA GAUGE AND INSTRUMENT CO.
1133 N. UTICA • TULSA, OKLA.

That's one way of describing boiler interiors when you use

SAND-BANUM

Pure Colloidal Concentrate
OUNCES ONLY ONCE A WEEK
Remove and Prevent
Boiler Scale and Corrosion

SAND-BANUM SPECIAL

Removes and Prevents Rust and Scale in ALL Radiator Cooling Systems

Send For Data

Gulf Coast District Representatives
WESTERN SAND-BANUM CO.
1717 Chenevert Street, Houston, Texas
COLLOID PRODUCTS CO.
2825 Storey Lane, Dallas, Texas

AMERICAN SAND-BANUM CO.
ESTABLISHED 1926
MEADOW BROOK NATIONAL BANK BUILDING
FREEPORT, NEW YORK

Harvey Fanshier Joins Corrosion Rectifying Company

Harvey Fanshier has been appointed Mid-Western representative for Corrosion Rectifying Company of Houston. Fanshier previously was in the Logging department of Lane Wells Company at Great Bend, Kansas, and was petroleum engineer for Petroleum Inc., an independent oil producing company at Great Bend, where he specialized in salt water disposal engineering and corrosion engineering.

Harvey Fanshier

A consulting corrosion engineer prior to joining Corrosion Rectifying Company, Fanshier will make his headquarters at Great Bend, Kansas.

International Harvester Changes Name of Division

The Industrial Power division of International Harvester Company is now known as the Construction Equipment division. The change applies to the name of the division only and does not affect personnel or line of equipment. Crawler tractors, industrial wheel tractors, two-wheel, high-speed earthmovers, towed scrapers, bulldozers, front-end loaders, engines, and off-highway trucks will continue to be marketed under the new division name of Construction Equipment division.

The new name was chosen to more accurately describe the products or activities of the division, Harald T. Reishus, vice president, announced.

In addition, International Harvester has announced management changes in advertising and sales promotion activities. Michael F. Peckels, former manager of the Consumer Relations department, was named director of consumer relations. He will be responsible for the operation of the sales operation research and Consumer Relations departments, as well as for operator manual and parts catalog functions. Peckels, who joined the company in 1915, has served in manufacturing, engineering and sales positions.

William O. Maxwell, formerly assistant manager of the Consumer Relations department, was promoted to manager of the department. Maxwell came to Harvester in 1941 as a general assistant to the supervisor of advertising, after being in advertising agency work. He held several positions in advertising, sales promotion and merchandising and was manager of merchandising services for Harvester's Foreign Operations department before his promotion to assistant manager of the Consumer Relations department in 1946.

Wilson and Day Named To Burgess-Manning Posts

The election of Allen Wilson of Chicago as a vice president and Dudley W. Day of Philadelphia as a member of the board of directors of Burgess-Manning Company has been announced. Wilson is manager of the company's Architectural Products division in Chicago and Day, also a vice president, is manager of the Penn Instruments division at Philadelphia.

Others renamed to the board of directors were Jackson Burgess, chairman; William C. Bennett, H. H. Darbo, R. L. Leadbetter and Willis L. Manning. Officers re-elected were Leadbetter, president; Day and S. G. Paddock, vice presidents; Manning, treasurer; E. D. Woisard, secretary and assistant treasurer; and A. W. Dreffein and C. C. Harris, assistant secretaries.

John H. Caldwell Joins Pittsburgh Coke & Chemical

John H. Caldwell has joined Pittsburgh Coke & Chemical Company as a salesman in the firm's Protective Coatings Division.

Caldwell, who will handle sales of the company's cold-applied coatings in the Gulf States area, had formerly been associated with S. D. Day Company, Houston.

made for rugged use...
in plant—office or field

Gotkool
water cans and coolers

"GOTKOOL" Water Cans are easily portable for field use . . . and **"GOTKOOL" Water Coolers** are especially designed for use in office, store, or plant. Both have extra large top openings. Snug-fitting, easily removable tops protect water from impurities. Heavy construction with heavy double-locked, sweat-soldered seams. *Buy* **"GOTKOOL"** *at your supply store today.*

GOTKOOL Water Cooler — made in 2, 3, 5, 8, 10, 15, and 20-gallon sizes with extended or recessed flush-mounted faucet optional. *(Note: 15- and 20-gallon sizes available with extended faucet only.)*

GOTKOOL Water Can — made in 1½, 2, 3, 5, 10, and 20-gallon sizes without faucets. Extended or recessed flush-mounted faucets available at slight additional cost. *(Note: 15- and 20-gallon sizes available with extended faucet only.)*

H. P. GOTT MFG. CO.
WINFIELD, KANSAS

KEEP PURE DRINKING WATER ALWAYS HANDY

William J. Flaherty

John M. McGivern

Polyken Division Announces Field Personnel Changes

The Polyken Sales division of The Kendall Company has announced new appointments in its protective coatings marketing program. William J. Flaherty and John M. McGivern have been newly assigned as market development specialists in the Merchandise department working directly with Howard D. Segool, merchandise manager, Chicago.

Flaherty, formerly Eastern field sales engineer for Polyken Protective Tape Coatings, will continue to work out of Philadelphia. McGivern, until recently associated with The Oil & Gas Journal, will headquarter in Tulsa, Okla.

Clark Bros. Names Dobbins Central Regional Sales Manager

William E. Dobbins has been named central regional sales manager for Clark Bros. Co. Dobbins will coordinate activities of the Houston, Tulsa and Chicago offices and make his headquarters in Houston.

William E. Dobbins

Dobbins has managed the Clark Bros. and Dresser Industries office in Washington the past 25 years and has been a special representative for Clark in the New York area.

Steel Tube Firm Opens Office in Houston

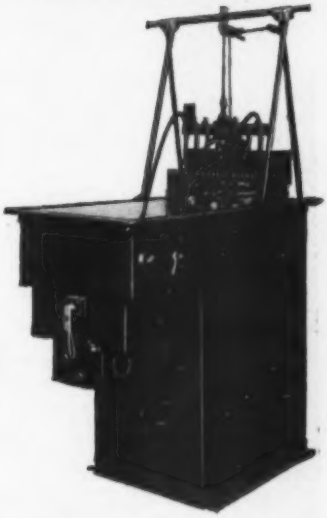
American Mannex Corporation, general agents in the U. S., Canada and Mexico for Mannesmann A. G. and its associated companies, has opened new and enlarged Southwestern headquarters in Houston. Mannesmann is Germany's largest integrated producer of steel and steel tubular goods.

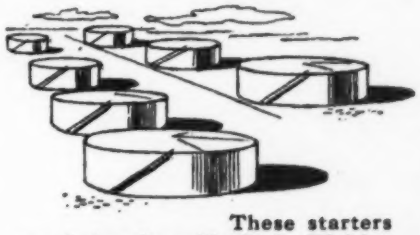
Under the direction of Hans Kayem, manager, the new office will be located in the Texas National Bank Building. The firm will continue to maintain a sub-office in Dallas.

The company announced expansion of its operation to include electric-weld line pipe from the ultra-modern mill of Mannesmann-Hoesch in Duisburg, just placed in operation. The firm's present production facilities, the various works of the Mannesmann Roehrenwerke in Germany, will soon be supplemented by the new mill of Cia. Siderurgica Mannesmann, Belo Horizonte, Brazil, which will be in full production within a few weeks; and the Mannesmann Tube Company, a new automatic mill in Sault Ste. Marie, Ontario, which will come into full production at the end of 1956.

EC&M

TOTALLY OIL IMMERSED
50,000 KVA
interrupting capacity
MOTOR STARTERS
have many advantages





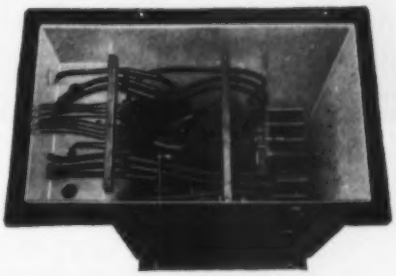
Contactor and Relay Panel are bolted together for raising as a unit above the oil. No leads or bolts to disconnect. Shown is Cat. No. 2645A Lifting Mechanism, available at small cost.

These starters are designed specifically for Division 2, semi-hazardous locations. They are low in first cost and are easy to service when inspection or maintenance are necessary. They require little floor space.

High interrupting capacity is inherent . . . 50,000 KVA and no power fuses required. The well-known Type ZHS Magnetic Contactor has been certified for this rating. It is of heavy-duty construction to assure trouble-free operation.

Before buying 2300-5000 volt motor starters, investigate EC&M Type ZHS Starters. They provide economy in installation, operation and maintenance, and are available in a range of horsepower sizes.

Write for Bulletin 1062-20.



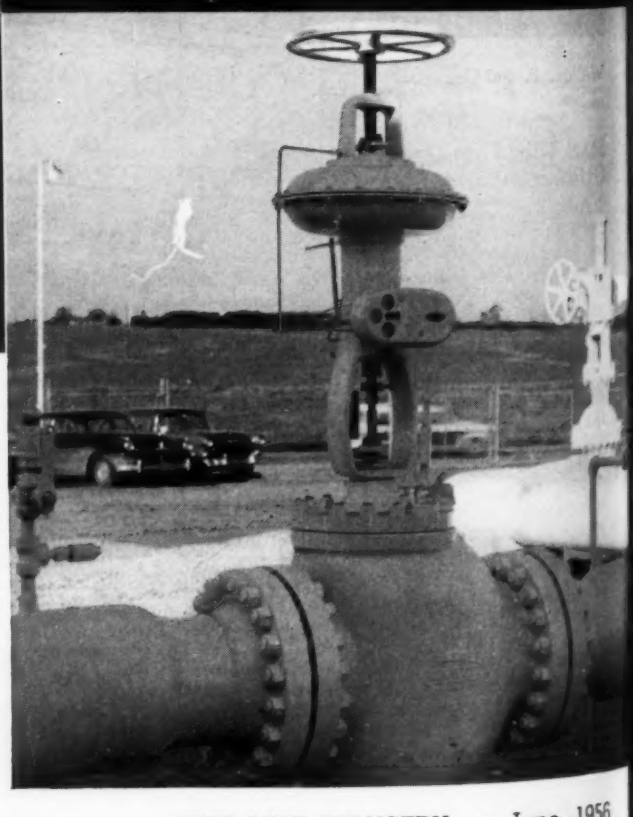
Looking down into starter showing anti-syphon lead construction from contactor, control transformer and overload relay panel to conduit connection box with threaded couplings. Starter with oil disconnect switch shown in views above.

8886-EC&M

THE ELECTRIC CONTROLLER & MFG. CO.
Division of Square D Company
4498 LEE ROAD • CLEVELAND 28, OHIO

For more data on advertised products, use Readers' Service Cards, last page.

The control room at Watson, California, the first station on the Western Branch. On the panel at the right is a Masoneilan 60000 Series Dual Selector Controller, with manual subpanel, and a Pressure Recorder. All controllers and auxiliary instruments for all stations were supplied by Mason-Neilan.



One of 15 Masoneilan 10000 Series Control Valves installed on the new pipeline. This one is a main line valve equipped with a Series 7400 Positioner for accurate, positive positioning.

Whinrey Named Vice President Of Link-Belt Company

Richard E. Whinrey, general manager of Link-Belt Company's Ewart plant in Indianapolis, has been elected a vice president of the company.

Richard E. Whinrey

Whinrey, who has been with Link-Belt since 1925, rose through the Estimating and Manufacturing department of the company's Dodge plant in Indianapolis to become assistant general manager in 1949 and the following year assumed similar duties at the Ewart plant, also in Indianapolis. Whinrey became general manager of the Ewart plant in 1951, succeeding Robert C. Becherer, who was elected executive vice president prior to his elevation as president of Link-Belt Company.

Martin L. Dion Joins Union Switch & Signal

Martin L. Dion has assumed responsibility for the administration and sales program for pipe line control equipment for Union Switch & Signal, Division of Westinghouse Air Brake Company.

Dion was a sales engineer for the Bristol Company and was southwestern district sales manager for The Electric Service Manufacturing Company, the position he held prior to coming with Union Switch & Signal.

Ted Davis Joins Sales Staff Of Delta Tank Manufacturing

Appointment of Ted G. Davis to the sales engineering staff of Delta Tank Manufacturing Company, Inc. has been announced.

Ted G. Davis

Davis formerly was active with a tank fabricator in Houston, Texas, and New Orleans, La. Prior to that he served for three years as a special agent for the Federal Bureau of Investigation in New Haven, Conn., and New York City.

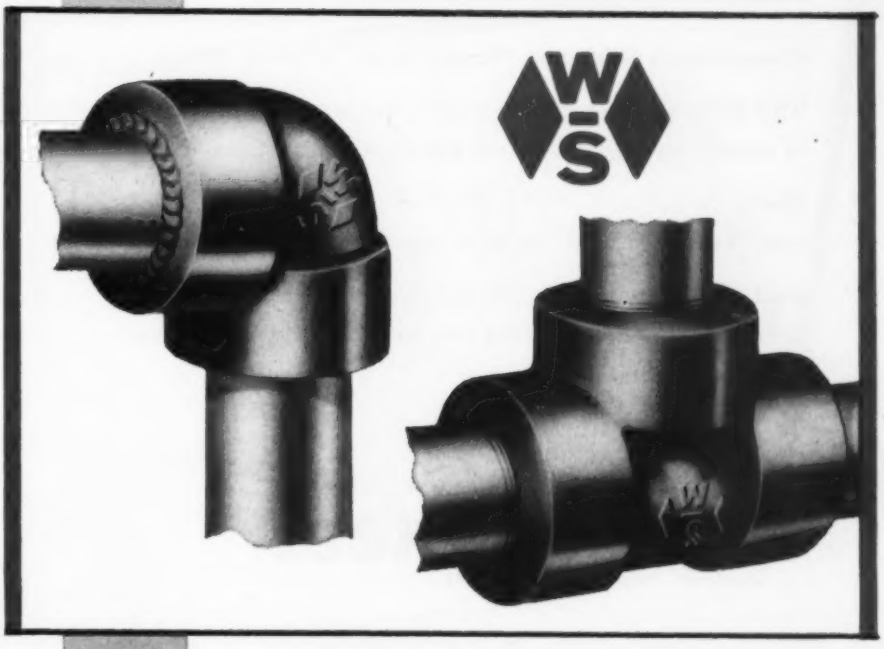
Davis is a graduate of Carthage High School, Carthage, Texas, and received his engineering degree from Texas A & M College.

Floe Elected Director Of Walworth Company

Dr. Carl Frederick Floe has been elected a director of Walworth Company. Dr. Floe is professor of metallurgy and assistant provost at the Massachusetts Institute of Technology. For many years, he has served industry as a consultant, particularly in the field of service behavior of metals and surface hardening of steel.

Dr. Floe received his doctorate in science from M.I.T. in 1935. He is a member of the American Institute of Mining and Metallurgical Engineers, American Society for Metals and American Society of Testing Materials. He is also director of the New England Materials Laboratory.

2 Safe Ways to PROTECT Pressure Piping...



W-S SCREW-END and SOCKET-WELDING FORGED STEEL FITTINGS

Pipe joints are potential trouble spots in high pressure piping systems. Change in direction of flow causes turbulence, erosion and vibration. Watson-Stillman fittings are made to absorb this type of punishment. They're drop-forged for strength and toughness and safety-factor designed for the protection of your piping.

Choose between a welded piping system and a screwed one to suit your needs. Then choose W-S Screw-End or Socket-Welding Fittings to join your pipe. They're available in sizes ⅛" to 4" for piping up to 6000 lb. W.O.G. class. For high temperature or corrosive service you can get W-S Forged Stainless and Alloy Steel Fittings, too. Send today for our informative catalogs.

W-S FITTINGS DIVISION

H. K. PORTER COMPANY, INC.
Roselle, New Jersey

For more data on advertised products, use Readers' Service Cards, last page.

IT'S NEARING COMPLETION...
PACIFIC NORTHWEST PIPELINE'S
"SCENIC INCH"

Winding across New Mexico's deserts, climbing the snow-capped Colorado Rockies and ending at last in the evergreen country of Oregon and Washington... Pacific Northwest Pipeline Corporation's 2300-mile "Scenic Inch" is being rushed to completion.

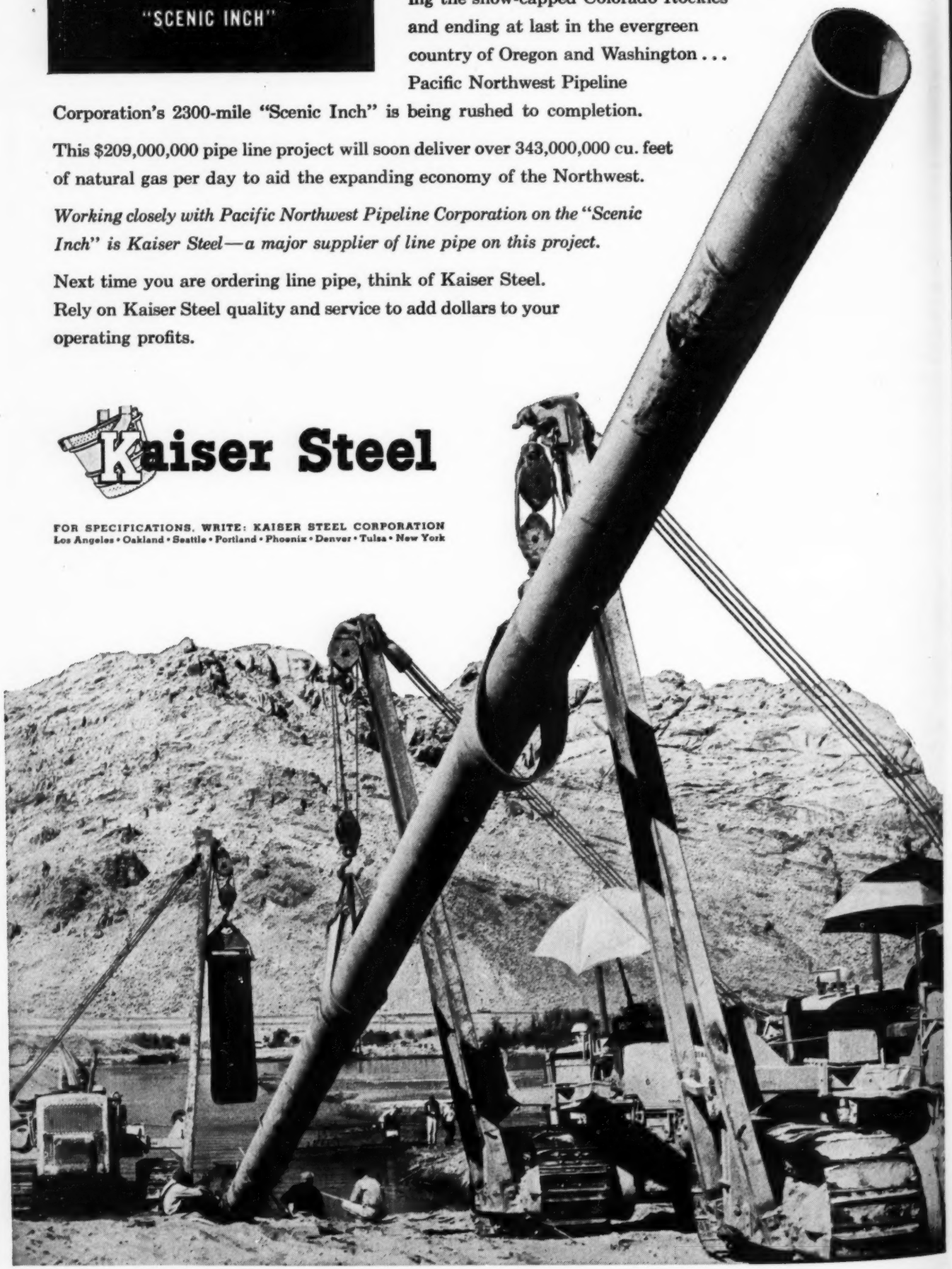
This $209,000,000 pipe line project will soon deliver over 343,000,000 cu. feet of natural gas per day to aid the expanding economy of the Northwest.

Working closely with Pacific Northwest Pipeline Corporation on the "Scenic Inch" is Kaiser Steel—a major supplier of line pipe on this project.

Next time you are ordering line pipe, think of Kaiser Steel. Rely on Kaiser Steel quality and service to add dollars to your operating profits.

Kaiser Steel

FOR SPECIFICATIONS, WRITE: KAISER STEEL CORPORATION
Los Angeles • Oakland • Seattle • Portland • Phoenix • Denver • Tulsa • New York



John G. Seiler Elected President of Tube Turns

John G. Seiler has been elected president of Tube Turns, a division of the National Cylinder Gas Company. Seiler succeeds George O. Boomer, who announced his retirement. Boomer will continue as chairman of the executive committee of the National Cylinder Gas Company.

John G. Seiler

Seiler joined Tube Turns in 1930 and became sales manager a year later. He was named vice president at the beginning of World War II and general sales manager in 1945. Seiler was elected a vice president of National Cylinder Gas Company at the same time he was elevated to the presidency of Tube Turns.

Recently Seiler was also appointed to the nuclear energy group of the Southern Regional Education Board sponsored by the Southern Governors' Conference.

Composed of leading industrialists and specialists in medicine, agriculture, manpower and education, the nuclear energy group will study peacetime applications of nuclear energy in the South.

Jones & Laughlin Opens New Store in Illinois

Construction of the new Jones & Laughlin Supply Division store and warehouse at St. Elmo, Ill. has been completed.

Store personnel includes Gerald Lee Berry, local store manager; Gerald H. Blair, Charles J. Gibson, Donald R. Gray and Billie J. Kelley, storemen; and C. W. Whitaker, sales representative.

U. G. White, Jr., district sales manager of Jones & Laughlin Supply division's Illinois-Kentucky district, directs the over-all activities of the St. Elmo store.

Allied Chemical & Dye Appoints Marketing Analyst

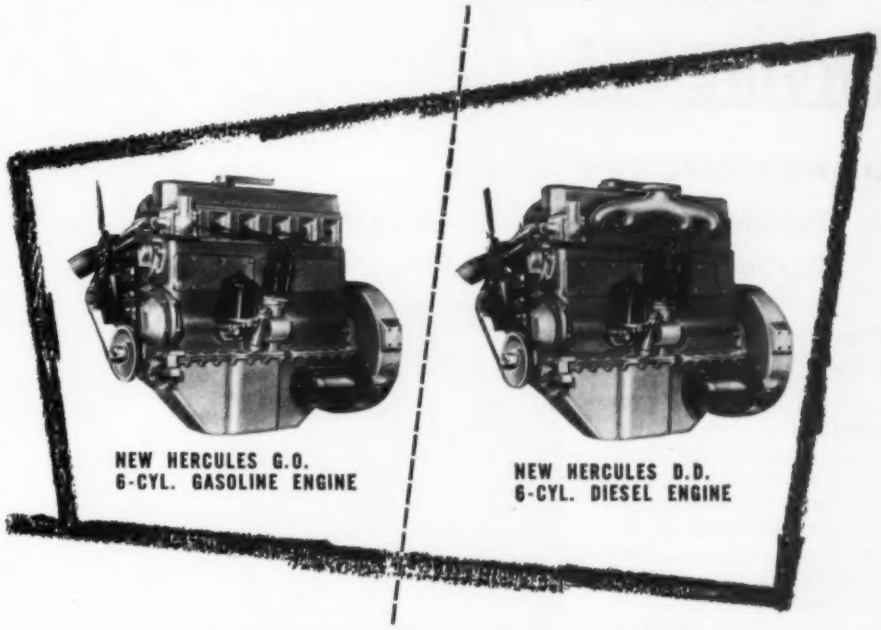
Gerald J. Bayern has joined the Barrett Division, Allied Chemical & Dye Corporation, as marketing and economic analyst. Formerly Bayern was assistant director of engineering with Foster D. Snell, Inc.

PIPE LINE INDUSTRY

"I see the land boys failed to get old man Jones to sell them a right-of-way."

WHEN YOU BUY AN ENGINE

. . . what's the first thing to look for?



Of course, some people look at the "outside" of an engine and see only a nice shiny paint-job. But that's not too important. Other buyers look at what's "inside" an engine. That can be very important. However, we think a buyer should also look at what's "back of" an engine. That's why we at Hercules Motors Corporation guard the enviable reputation we have earned in more than 41 years of engine building experience.

Hercules' reputation isn't merely a way of doing business or just the top quality of our product. We feel that our reputation means more than good business ethics and a quality product. Our reputation also means supplying new and better engines to meet the various needs of our customers.

As an example, our new line of INTERCHANGEABLE engines gives the customer the choice of gasoline or diesel power without changing engine mountings in the end product. These new G.O. (Gasoline Overhead valve) and D.D. (Direct injection Diesel) engines, not only have the same mounting dimensions in engines of the same number of cylinders, but many component parts are also interchangeable over the entire range of these new models.

Years of engine building "know how" stand "back of" every Hercules Engine. In addition, our wide selection of more than 90 models of engines and power units, available for operation on gasoline, diesel fuel, natural gas, L.P.G. and kerosene, provides a dependable source of power for all requirements between 3 and 500 H.P.

For help in solving your power problems, contact our factory. Our sales-engineers will be glad to assist you. No obligation, of course.

HERCULES MOTORS CORPORATION

CANTON 2, OHIO

For more data on advertised products, use Readers' Service Cards, last page.

A New Concept in *FULL-FLOW* Filters...

ENGINE LIFE *Maxiflo*

UNRESTRICTED CORE

DESIGNED TO GIVE MAXIMUM FLOW AND FILTRATION

Conditions oil without restricting flow

Here's a brand new ENGINE LIFE exclusive that gives unrestricted oil flow without sacrificing strength. This new core development which required research and development of special machines and tooling right in our own plant, gives you the finest full flow oil filtering yet. Now, even the most viscous lubricating oils and fuels are filtered perfectly. Because core openings can handle up to 10 times the oil pumped through the system, the most excessive surges are easily handled, thereby protecting the hydraulic system from undue restriction and ultimate failure. All integral parts of the new Maxiflo core are of non-corrosive metal.

New core perforation, instead of removing metal from openings, keeps all the metal pronged to give element structural strength and prevent filter media from sagging
ENGINE LIFE

With Maxiflo, as in all Engine Life Elements, consistency in diameter and length is maintained

ENGINE LIFE elements operate without impairing the hydraulics of your engine. Better oil conditioning is achieved through the ENGINE LIFE absorption method of full filtration. All ENGINE LIFE elements are engineered to meet requirements of your application.

ENGINEERED FOR ALL REQUIREMENTS

Lubrication system flow rates are maintained by the free area ratio of perforation. Openings equal up to 10 times amount of oil volume pumped through engine.

Non-corrosive Metal Cores are end sealed with metal rings to insure trueness, add lip strength.

ENGINE LIFE *PRODUCTS CORPORATION*

EL MONTE, CALIFORNIA

ENGINEERED FILTRATION SERVICE

INDUSTRIAL AUTOMOTIVE MARINE & AGRICULTURAL

As SIMPLE and Dependable as the Pull of a MAGNET!

A sleeve, raised and lowered within a non-magnetic tube, attracts or releases an Alnico magnet attached to a mercury switch. Basically, this is Magnetrol.

MAGNETROL

The Simplest, Most Versatile LIQUID LEVEL CONTROL *Ever Devised!*

Linked to liquid level by infallible magnetic force, Magnetrol is free from the limitations inherent in mechanical or electrical controls. With the actuating magnet rated at 98% of initial strength after 30 years, Magnetrol has *infinite operating life,* with practically no maintenance at all. There are no wearing parts to get out of order.

What's more, Magnetrol's simple operating principle permits easy, economical modification of standard units to meet *any* pressure, temperature or corrosion requirements. That's why there's practically no limit to Magnetrol's use. It's also why "specials" are likely to be standard with us. Magnetrol units control level changes from .0025-in. to 150-ft. —with single or multi-stage switching.

MAGNETROL, Inc.

● *SEND COUPON FOR DETAILS*

MAGNETROL, Inc. 2128 S. Marshall Blvd., Chicago 23, Illinois
Please send me catalog data and full information on Magnetrol Liquid Level Controls.
Name
Company
Address
City Zone State

Muchnic Elected Director Of Rockwell Manufacturing

William H. Muchnic, president of Locomotive Finished Materials (or LFM) Company of Atchison, Kansas, which merged with Rockwell Manufacturing Company in February, has been elected a director of Rockwell.

William H. Muchnic

The election was announced following Rockwell's annual stockholders meeting in Pittsburgh. Ten other directors were re-elected at the meeting.

Muchnic, president of LFM since November 1952, joined the company as a plant engineer in 1946 and was named assistant to the president in 1948. He is a director of the Steel Founders Society of America and was formerly chairman of its product development committee.

Allis-Chalmers Appoints Rhoten to Post in England

Myron W. Rhoten has been named managing director of Allis-Chalmers Great Britain Limited with headquarters in Essendine, England. Rhoten was European territory sales manager for the Allis-Chalmers Manufacturing Company, Tractor Group, since February, 1953.

Rhoten has been with Allis-Chalmers since 1938 and succeeds E. J. Mercer, who returned this year as general manager of the Tractor Group's Construction Machinery division. Mercer went to England in 1951 as general manager and was appointed managing director when the English subsidiary was formed.

Chicago-Wilcox Appoints California Distributor

The appointment of PenPower, Inc., to handle sales and service on their gaskets, shims and washers in California has just been announced by Chicago-Wilcox Mfg. Company.

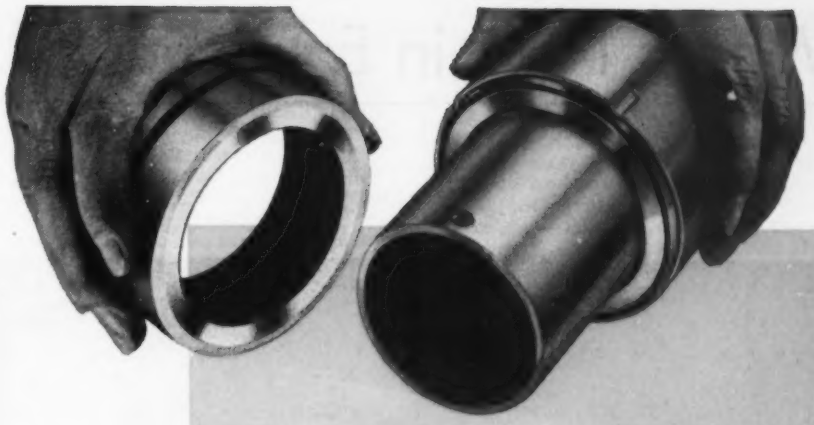
PenPower maintains Los Angeles headquarters at 1135 West Huntington Drive, Arcadia, and a San Francisco district office at 340 Lorton Avenue in Burlingame.

Oil Well Supply Transfers Several Field Representatives

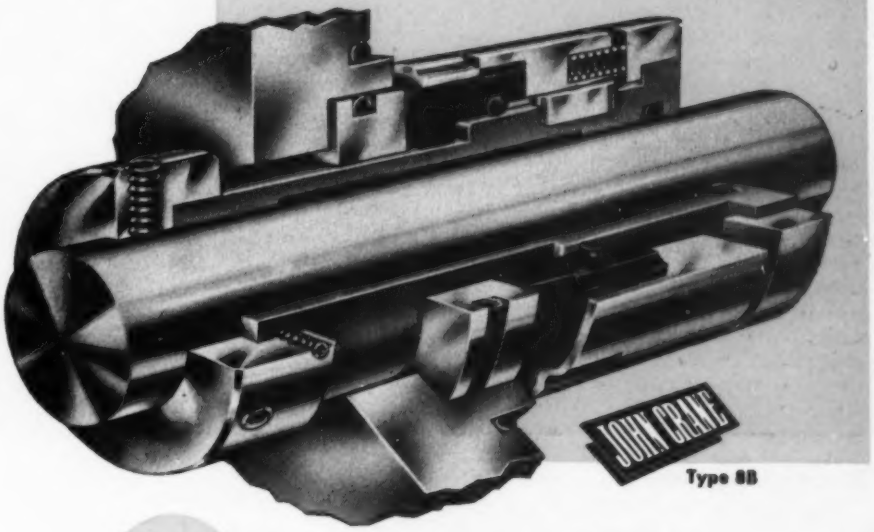
Oil Well Supply division of U. S. Steel has announced the transfer of several field representatives. James M. Ireland is transferred from Long Beach, Calif., to Huntington Beach, Calif.; Norman E. Cordell from Clay City, Ill., to Mattoon, Ill. and Billy E. Smith from Huntington Beach to Long Beach.

Fisher Governor Company Buys Control Specialty Corporation

Fisher Governor Company of Marshalltown, Iowa, announces the purchase of Control Specialty Corporation, Houston. Manufacture of lease automation equipment, tank switches, well testers and other associated products will be continued at the Houston plant, which will operate as a subsidiary of Fisher Governor. Sales and service representation will be available through exclusive Fisher representatives.



THIS IS THE SEAL USED IN 75% OF ALL RECENT PIPE LINE PUMP INSTALLATIONS



Type 8B

These Important Facts Tell Why

Reports from the field reveal that after 2½ years of continuous operation "John Crane" Type 8B Seals are still in perfect operating condition. This adds up to over 20,000 hours without shutdown!

Man-hours are being saved. The 8B is quickly installed and adjusted simply by sliding the entire unit along the shaft into position. The top casing need not be removed.

High pressure problems are eliminated. "John Crane's" exclusive hydraulically balanced construction permits handling of pressures up to 1200 psi.

The 8B comes in a full range of sizes to meet individual specifications and can be engineered to practically any on-the-job requirement.

***Be sure you get "John Crane" 8B Seal performance.* Contact Crane Packing Co., 6434 Oakton Street, Morton Grove, Illinois (Chicago Suburb).**

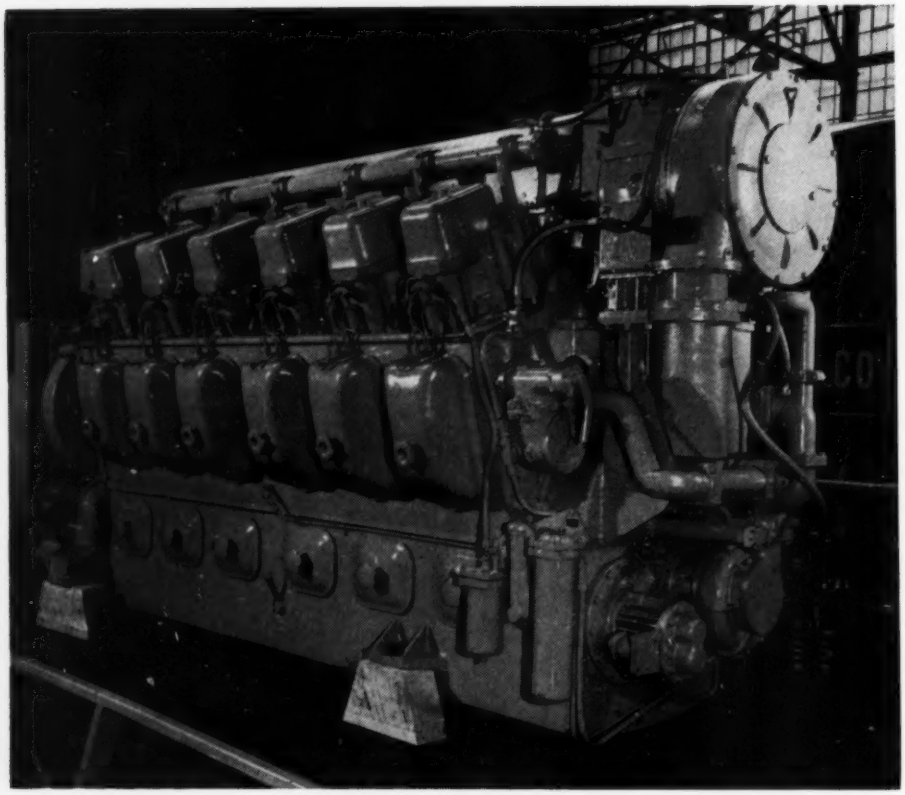
In Canada: Crane Packing Co., Ltd., Hamilton, Ont.

CRANE PACKING COMPANY

For more data on advertised products, use Readers' Service Cards, last page.

What's New in Equipment

for the Pipe Line Industry



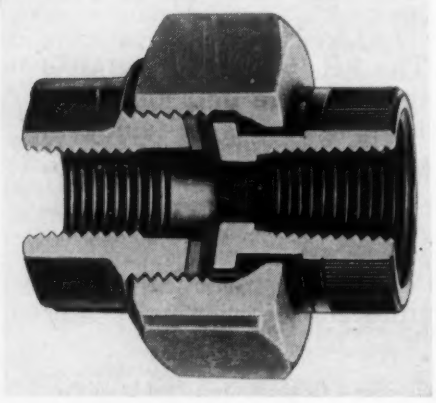
Diesel Engine

Alco Products, Inc., has introduced the new Alco 251 diesel engine now available in the straight 6-cylinder and 12 and 16-cylinder Vee-type models. The new engine was recently exhibited at a meeting of the Oil and Gas Power division of the American Society of Mechanical Engineers.

The 251 engine is available for various stationary uses, including pipe line pumping stations, in addition to its application in drilling rig power packages and for main marine propulsion.

(This item supplements Alco Products, Inc., data on pages 153-172 of the Composite Catalog, 21st edition.)

For more data circle **No. E1** on Readers' Service Card, last page this issue.



Insulating Unions

Eclipse Fuel Engineering Company has announced a new line of insulating unions designed to stop electrolytic corrosion of mains and services.

Jumping or shorting of induced or stray house currents across the union is eliminated by the Wedgeseal insulator, which extends over the flange and washer face. The new Zytel 105 insulator combines high strength with improved insulating qualities.

Installation costs are reduced because the tough new insulator is an integral part of the tailpiece and requires no assembly. Mating tapers in the insulator produce a wedging action which assures a tight fit without shearing action between the tailpiece and the nut. Wedgeseals will withstand 350 ft. lb. of applied torque and will not break in service.

Maintenance costs are reduced by the ability of the insulator to withstand line sag. Also they are climate-proof, unaffected by natural, manufactured, or LPG and will not pull out, shear off or crack.

Every Wedgeseal is tested at 150 pounds and is form stable at 400° F., suitable for continuous operation at 275° F. Sizes available are ¾-inch and 1-inch; additional sizes may be obtained soon.

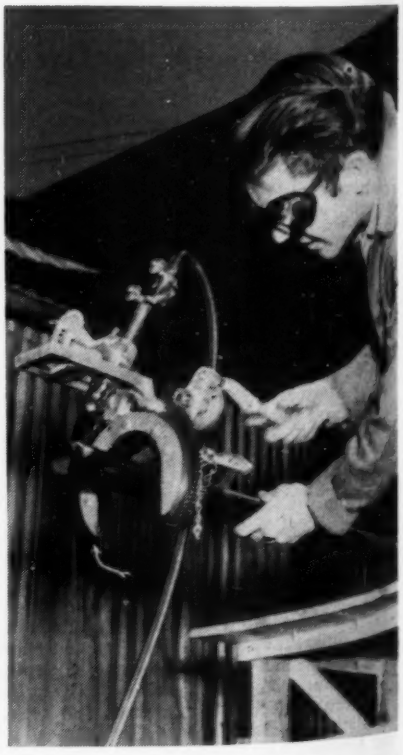
For more data circle **No. E2** on Readers' Service Card, last page this issue.

Pipe Cutter

A completely portable flame cutting and pipe beveling machine for small diameter pipe has been introduced by the H & M Pipe Beveling Machine Company. The new unit is expected to have wide application in industries where the fabrication and use of small diameter piping is an important factor. The smaller machine is constructed on the same design principles as larger H & M models, and patents have been applied for on certain features.

The new H & M Model O cutter is portable, weighing 7½ pounds, and assures perfect, square bevels under all conditions. Using the same split-gear horseshoe principle which characterizes the company's larger units for pipe up to 36-inch, the new, smaller model allows the operator to place the machine on continuous pieces of pipe. A quick operating specially designed boomer strap speeds up the process of changing the machine from one piece of pipe to another.

Changing the unit from one size of pipe to another is a matter of replacing precision-made adapters, properly identified for the various pipe sizes. The change from the smallest to the largest pipe size can be made in seconds. Any plain barrel machine cutting torch may be used with the unit.



For more data circle **No. E3** on Readers' Service Card, last page this issue.

Shovel Crane

The largest production model shovel-crane yet produced by Link-Belt Speeder, the three cubic yard K-608, has been added to the Link-Belt line. The crawler-mounted K-608 is convertible to shovel, crane, dragline, clamshell and piledriver attachments. The machine is designed for three-yard shovel operation with rated crane lifting capacity of 75 tons at 12-foot radius.

The K-608 has speed-o-matic true power hydraulic control, a fingertip-operated, quick-response system said to offer up to 25 percent greater output than similar sized machines with manual controls. Hydraulic pressure is produced through a pump driven by the engine. Pressure is metered to the clutches by variable pressure control valves that the operator opens and closes with short, fingertip controlled levers to provide immediate, smooth actuation of all clutches.

Standard power equipment consists of torque converter and engine combination, matched for greater horsepower output, consequently greater production, during the the digging cycles. Both the upper and lower frames are all-welded and stress-relieved to insure maximum strength and life under severe, shock-loading conditions.

Digging brakes, controlled from the cab, serve as both steering and digging brakes. Hydraulically actuated, they have capacity to hold the machine on any workable grade. Spring-loaded and hydraulically released, they are applied automatically when travel jaw clutches are disengaged.

(This item supplements Link-Belt Speeder Corporation, Division of Link-Belt Company, data on page 2996 of the Composite Catalog, 21st Edition.)

For more data circle **No. E6** on Readers' Service Card, last page this issue.

Field Jointer

Greenhead Sling and Supply Company has introduced a new field jointer designed to save time in application and provide ease in application. Adapted for either hot dope or concrete coatings, the field jointer costs less than conventional metal forms. It is shipped as a complete package unit and all sealing and gasketing material is attached.

In actual use no leakage is found where the felt gasket seals each edge of the jointer; the bottom of the jointer stays rigid, permitting no sag. All these factors facilitate application and ease in handling.

Made of flexible hardwood plywood bonded between two layers of heavy kraft, the jointer is available in any width or length in size to suit any requirement.

For more data circle **No. E4** on Readers' Service Card, last page this issue.

Precision Timer

Roberts Electric Company is manufacturing a simplified precision ignition timer, the R & H precision timer, which is important for good engine operation. The mechanical design of the R & H precision timer is similar to the high tension distributors used successfully by the automotive industry; however, it is a low tension distributor. It features a single breaker point to interrupt the primary circuit to all cylinders on an engine and basically is different from other low tension distributors which use a separate set of breaker points for each cylinder.

Among the advantages of the timer are one set of breaker points, the maintaining of correct point of ignition for all cylinders, thereby eliminating unbalanced load between cylinders once air fuel ratio is correctly set, and high velocity of breaker point opening which reduces the rate of pitting and erosion. The timer also has simplicity of timing and simple rugged construction with a minimum of wearing parts.

For more data circle **No. E5** on Readers' Service Card, last page this issue.

WILLIAMS BROTHERS

ENGINEERS and CONSTRUCTORS

RECENTLY COMPLETED
Oleoducto del Pacifico
Colombia, South America

OIL • GAS • WATER
PRODUCTS PIPELINES
PUMPING STATIONS

HOT BLDG • TULSA, OKLAHOMA • CABLE ADDRESS: WILLBROS
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ENGLAND

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for safety first and protection that lasts!

TOWER'S

Neoprene Clothing

Wherever personnel safety can be threatened by the lack of adequate protection from greases, oils, water, most acids and chemicals, that's where TOWER'S *extra protective* Clothing belongs. These comfortable, designed-to-fit garments are made of strong, impregnated fabric and are coated inside and out with hazard-resistant Neoprene Latex. Coats, jackets, overalls, hooded shirts, hats and aprons . . . for *every* industrial use. For complete information mail coupon today, or if you have a particular problem, let us know and we'll solve it quickly with the garment best suited to your needs.

for Neoprene Latex Clothing — TOWER'S FISH BRAND — TOWER'S ARROW BRAND — for Rubber Latex Clothing

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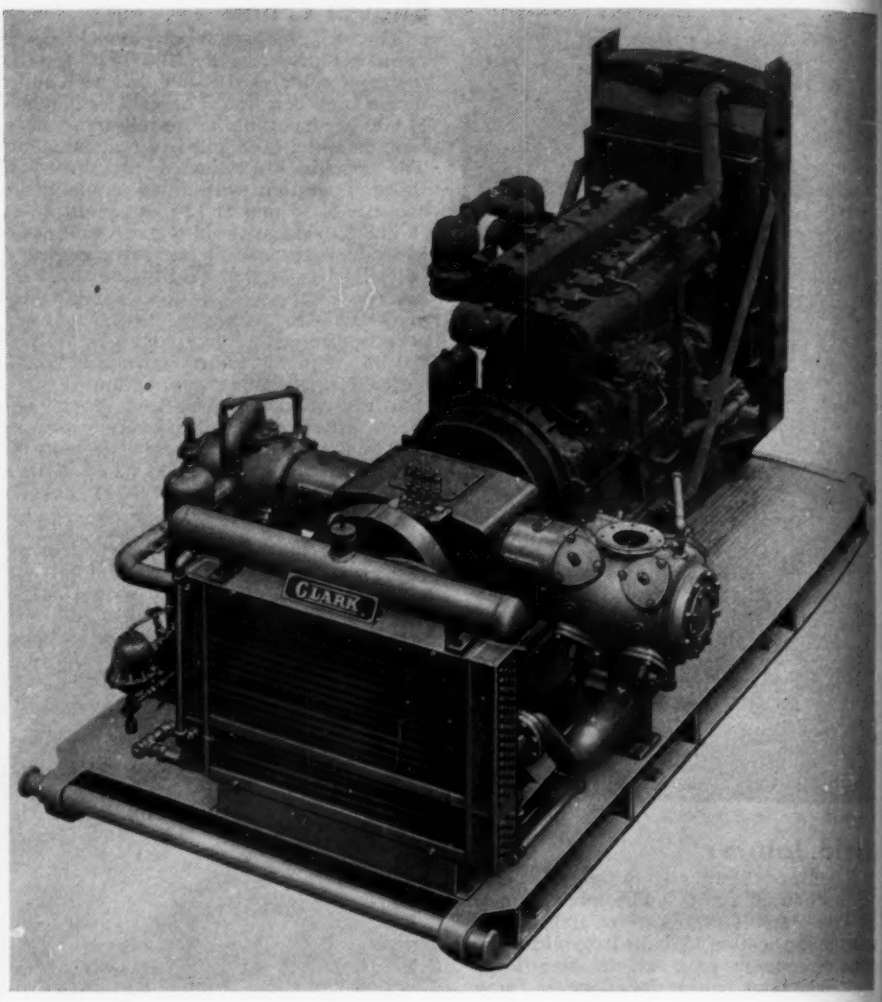
A. J. TOWER CO.
A Division of Sawyer-Tower, Inc.
Boston 20, Mass.



New Field Compressor

This new CFA packaged compressor, manufactured by Clark Bros. Company, has been specially designed for oil and gas field use. It is well suited to gas gathering, gas lift, and other applications requiring a unitized compressor station in the 75-200 horsepower range.

The unit consists of a newly-designed balanced/opposed compressor mounted on a steel skid and direct driven by an oil field type gas engine. A radiator is included to permit intercooling of the gas between stages and to cool the lube oil and compressor cylinder jacket water. A scrubber and dump trap can be provided to remove condensate and moisture from the gas stream between stages.

In the balanced/opposed principle, the compressor cylinders, which are mounted on opposite sides of the crankcase, are driven from crankshaft throws which are 180 degrees apart. Reciprocating masses are always moving in opposite directions. Therefore, because each reciprocating force is opposed by an equal and opposite force, there are no unbalanced vertical or horizontal forces; they are all cancelled out. The compressor is virtually vibrationless in operation.

Since the skid measures only 7 by 15 feet, it is readily adaptable to operation on floating barges or on trucks or trailers.

(This item supplements Clark Bros. Company, Inc., data on pages 1290-1291 of the Composite Catalog, 21st Edition.)

For more data circle **No. E7** on Readers' Service Card, last page this issue.

Bimetallic Dial Thermometer

Taylor Instrument Companies has announced a new bimetallic dial thermometer for such industrial and institutional services as pipe lines, hot water tanks, storage tanks, etc.

Easy to read and accurate within plus or minus one percent of range over the entire range, the thermometer is available with three or five-inch dials and stem lengths of four, six, nine and 12 inches. Separable wells of brass, steel, type 304 stainless steel or Monel are available. Ranges of the various instruments run from minus 40° to plus 750° F. All exposed metal parts are of arc-welded corrosion-resistant stainless steel.

Instruments are waterproof and mechanical connections are welded for greater toughness and reliability. There is no ambient temperature effect. Over-range protection is 50 percent up to 500° F. and 10 percent above 500° F. All instruments, except for the unit having the 200° to 750° F. range are silicone-damped against vibrations. This results in increased speed of response, absence of zero shift due to shock, minimum pointer vibration and elimination of pointer chatter when the thermometer is handled.

(This item supplements Taylor Instrument Companies data on Page 4833 of the Composite Catalog, 21st Edition.)

For more data circle **No. E8** on Readers' Service Card, last page this issue.